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# European Science Notes

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# European Science Notes

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## Biological Sciences

- Center of Molecular Biology, Canto Blanco  
(Madrid), Spain ; ..... Claire E. Zomzely-Neurath 117

The organization and activities of this institution are reviewed in some detail. Its scientists are working in a wide variety of research projects in genetics, cell biology, neurobiology, biochemistry, and microbiology. They are making important contributions to the research in these fields.

- Life Sciences Research at Trent Polytechnic,  
Nottingham, UK ; ..... Claire E. Zomzely-Neurath 123

This article on Life Sciences at Trent Polytechnic shows that this relatively new and small department is engaged in a wide variety of research projects. Its liaison with industry helps bring laboratory results into the commercial market.

## Computer Sciences

- Artificial Intelligence at Milan ; ..... Paul Roman 126

This article is based on a visit to three active (AI) research centers in Milan: a unit of the Polytechnic; a section of the R&D institute, CISE; and a division of the private development and manufacturing firm, FIAR. The highlights described include a universal problem solver, representation of procedural knowledge in expert systems (ES) and relevance to process control, and an advanced sensor fusion ES.

## Material Sciences

- Ceramic Matrix Composites ; ..... Kenneth D. Challenger 130

The fracture of brittle matrix composites was the topic of EUROMECH 204 held in Jablonna, Poland. The papers on composite ceramics and metal-to-ceramic bonding are reviewed in this article.

## Mechanics

- Fluid Mechanics, Combustion, and Hydroacoustics  
at Bertin ..... Eugene F. Brown 133

This review of the activities of Bertin and Co. concerns their work in fluid dynamics, combustion, and hydroacoustics. It is clear that Bertin, an applied research organization, excels at technology utilization and is involved in a number of projects which should be of interest to the US Navy.

Fluid Mechanics Research at Laboratoire National d'Hydraulique (L.N.H.),.....	Eugene F. Brown	136
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This article on the Laboratoire National d'Hydraulique highlights the work of the Research and Industrial Fluid Mechanics Group. Although their work is not directed to areas of specific interest to US Navy needs, there is enough work going on in fundamental areas to warrant continued attention.

## Physics

Lasers and Electro-Optics at CISE in Milan .....	Paul Roman	139
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Research and development in the lasers and electro-optics area of a large, independent, multi-disciplinary laboratory complex near Milan is reviewed. High power lasers and laser systems, lidar work, interferometric optical fiber sensor studies are highlighted.

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## Biological Sciences

### CENTER OF MOLECULAR BIOLOGY, CANTO BLANCO (MADRID) SPAIN

by Claire E. Zomzely-Neurath. Dr. Zomzely-Neurath is the Liaison Scientist for Biochemistry, Neurosciences, and Molecular Biology in Europe and the Middle East for the Office of Naval Research's London Branch Office. She is on leave until July 1986 from her position as Director of Research, the Queen's Medical Center, Honolulu, Hawaii, and Professor of Biochemistry, University of Hawaii School of Medicine.

#### Introduction

The Molecular Biology Center is located in Canto Blanco, a suburb of Madrid, on the same campus as the relatively new University Autonomous of Madrid. Although the Center is affiliated with the university, its primary function is research. While the staff members, including professors, are not required to teach courses at the university, many do participate in the teaching curriculum of the university but, in general, only through specialized lectures in their research areas.

The Center was organized in 1975 with the aim of providing an interdisciplinary research center, using a common technical department, material, administrative resources, etc. To form the Center, three institutes--one from the university and two from the Higher Scientific Research Council--joined with the Section of Developmental Genetics of the Council. They kept their autonomy but also developed collaborative programs within the Center and with the university. According to G. Ramirez, the present director, the Center has reached the necessary critical capacity. The total staff today numbers 300, including professors, technical assistants, graduate students, post-doctoral fellows, and administrative staff. Financial support for the Center is provided by several government agencies such as the Fund for Health Research and the Commission for Scientific and Technical Research. The organization is shown in Table 1.

A representative governing board oversees the activities of the Center. This board is the chief governor and executor of the center. Members include the Directors of the three Institutes and of the Section of Developmental Genetics, the administrator, four re-

search personnel representatives, and two representatives from the technical department.

The Spanish government has obviously invested substantial funds in setting up the Center, as the buildings are modern with well-designed laboratories containing first-class equipment.

A wide range of research projects is being carried out; additional projects emphasizing the use of recombinant DNA methods are being initiated.

#### Some Research Projects at the Center of Molecular Biology

Metabolic Regulation and Aging. A. Machado and colleagues have been engaged in studies of the regulatory role of the NADPH/NADP ratio in modulating metabolic processes. They have studied the possibility that metabolic processes such as the glyoxylic acid cycle could be modulated by the redox state of NADP. The function of the glyoxylic acid cycle in *Tetrahymena pyriformis* and *E. coli* depends on inhibition of the NADP isocitrate dehydrogenase. Machado et al. have found that NADPH is an inhibitor of this enzyme in these organisms and that under conditions of glyoxylic acid-cycle function the NADPH/NADP ratio increased and isocitrate flux through isocitrate dehydrogenase decreased. These findings support the hypothesis of Machado et al. that NADP isocitrate dehydrogenase inhibition and glyoxylic acid-cycle function are modulated by the NADPH/NADP ratio.

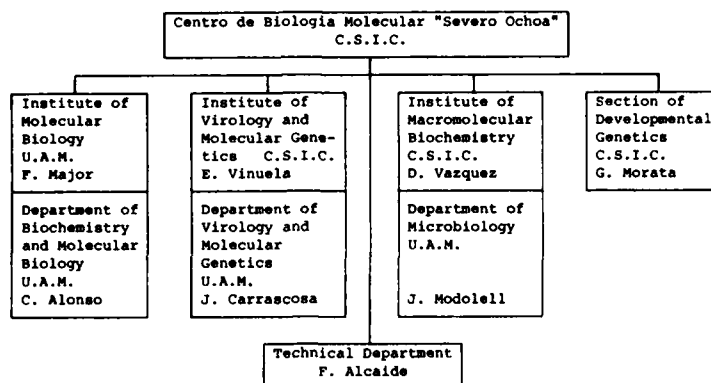
Machado and coworkers have also investigated the age-dependent behavior of a number of enzymes linked to energy metabolism during the lifetime of the rat in three organs: liver, brain, and heart. No substantial alterations in enzyme activities were apparent in the old rat brain, but significant variations were observed in old liver. Pyruvate kinase activity decayed whereas a number of tricarboxylic acid-cycle enzyme activities increased or remained unchanged during senescence. NADP-malic enzyme and ATP-citrate lyase activities showed age-dependent decreases, indicating that the liver lipogenic activity is probably diminished in old animals. Machado et al. have also shown that the two gluconeogenic enzyme activities, phosphoenolpyruvate carboxykinase and glucose-6-phosphatase, increase during senescence; this suggests that basal gluconeogenesis is possibly enhanced in the old rat liver.

In the heart, aging resulted in a rise of most mitochondrial enzyme activities studied (NADP-isocitrate dehydrogenase, malic enzymes, succinate



Table 1

## Organization of the Molecular Biology Center



dehydrogenase, citrate synthetase). Exceptions were NAD-isocitrate dehydrogenase and NAD-malate dehydrogenase. A concurrent parallel study showed that mitochondrial volume fractions also increase with development. Senescence changes in the rat heart followed two different trends: a decrease in pyruvate kinase and those mitochondrial enzymes lying between citrate formation and isocitrate oxidation and, over the same period, an increase in mitochondrial NAD-malate dehydrogenase and succinate dehydrogenase activities. Machado et al. think that these results point towards an impairment of the tricarboxylic acid-cycle function and reduced energy-producing capacity in the aged rat heart. Also, these enzyme activities were paralleled by an increase in myelin-like figures and lipid complexes that appeared in the aged rat heart, suggesting that lipid oxidation is also defective.

**Chromosome Structure and Function.** C. Alonso and coworkers have investigated the induction and distribution of chromosomal transcripts in the polytene chromosomes of *Drosophila melanogaster* and *Drosophila hydei* by indirect immunofluorescence using an antiserum directed against DNA/RNA hybrids. The fluorescence was intense and occurred in most of the chromosomal subdivisions when the chromosomes were exposed to denaturing conditions and then allowed to reanneal. The extent of hybrid formation depended both on the extent of DNA denaturation and on the maintenance of RNA integrity. Fluorescence was absent from chromosomes treated with pancreatic RNase before denaturation. The velocity of the chromosomal DNA/RNA hybridization reaction and the effects of the initiation inhibitor

of RNA synthesis, DRB, suggest that in order to hybridize, the RNA has to be located in its transcriptional compartment. Even though overall patterns of fluorescence seemed to be similar during a developmental stage, variations were observed, particularly some correlated with puff induction after ecdysone stimulation.

Alonso et al. have also characterized at the molecular and cytological level a small region at locus 63F in the left arm of chromosome 3L and situated within an early ecdysone puff site. The sequence contains a 2.5 kb internally repeated fragment with a repetition unit sequence of 180 nucleotides. *In situ* hybridization studies show some fixed and some variable locations for the fragment in *Drosophila melanogaster*. Among the variable locations there is another early ecdysone site in *Drosophila simulans* (region 2B) and the nucleolus of several species. Transcription is very active at this locus, and Alonso et al. have identified five RNA products of sizes 4.1, 3.8, 2.1, and 0.6 kb. The RNA families of 4.1 and 2.1 seem to be polymorphic in different stocks of flies. Alonso et al. are trying to identify protein products for these RNA transcripts. They are also investigating possible relationships between the characterized "dancing" fragment and other types of molecules such as mobile elements, small and stable RNA, or retrovirus-like sequences.

**Molecular Biology of Development in *Drosophila*.** J. Modolell and his research group are studying various aspects of development in molecular terms, using *Drosophila melanogaster* as a model system. They have focused on the molecular analysis of the *achaete-scute* gene

complex of *Drosophila melanogaster*. This complex is involved in the differentiation of innervated elements in the adult (sensory region) and in the embryo (central nervous system). Modolell et al. have cloned part of the DNA of the *achaete-scute* complex entering the DNA of the *scute* region by using a small fragment of it. This was accomplished by taking advantage of a DNA probe containing a transposon-like sequence known to be inserted in the *scute* region of the *scute* mutation. Approximately 100 kb of DNA of the complex has been cloned. This work was done in collaboration with M. Meselson, Harvard University, Boston, Massachusetts. The analysis of the DNA alterations associated with mutations with chromosomal rearrangements has revealed that a large part of the cloned DNA corresponds to the genetically defined *scute* 8 region. Most of the available "point mutations" also show alterations in the DNA of the cloned region; surprisingly, these are large alterations--0.6- to 7-kb insertions or 1.6- to 15-kb deletions. Modolell et al. are continuing with the cloning of the rest of the DNA of the *achaete-scute* complex. They are characterizing its transcriptional products, four of which have been detected. They are also studying the alterations of the transcripts in the *scute* mutations. Their aim is to elucidate the organization of the gene complex involved in development.

#### African Swine Fever (ASF) Virus.

E. Vinuela and colleagues have been carrying out studies of the ASF virus. The target cells of this virus are the mononuclear phagocytes (monocytes, macrophages) which are non-dividing cells. This has made it difficult to produce ASF virus *in vitro* in amounts large enough for biochemical studies. Previously, peripheral monocytes which are present in blood at a concentration of only  $2$  to  $5 \times 10^5$  cells/ml had been used. Vinuela et al. have partially overcome this problem by using a bronchoalveolar lavage obtained from pigs from which pure cultures of macrophages ( $1$  to  $2 \times 10^9$  macrophage per pig) can be obtained. The virus has been purified from the culture media of infected VERO cells by differential centrifugation, density gradient centrifugation in Percoll gradients, and exclusion chromatography in Sephacryl S-100. The yield of infective units was about 20 percent and the virus/vesicles ratio about 20, a value which is at least 20-fold larger than that obtained by equilibrium centrifugation in sucrose gradient. The only glycoprotein detected in the purified virus is a minor component of 65,000 molecular weight, which might be

a contaminant from the vesicles still present in the purified virus. The genome of ASF virus has been found to be a linear duplex of about 170 kbp with covalently closed ends and 2.1-kbp-long inverted terminal repetitions (ITR) similar to those present in poxvirus DNA. Besides the ITR, the DNA also contains imperfectly matched internal inverted repetitions with a length of about 140 bp or multiples of it. A library of molecular clones of restriction fragments accounts for about 98 percent of ASF virus DNA, the missing sequences being those removed by the nuclease S1 used in the process of cloning the cross-linked terminal fragments.

The RNAs made *in vivo* in ASF virus-infected cells, in the presence of either cyclohexamide or cytosine arabinoside, hybridized with the same DNA regions. These regions are also the ones which hybridized with the RNAs synthesized *in vivo* by the ASF virus RNA polymers. Many of those RNAs selected by hybridization to DNA restriction fragments were translated into viral proteins by a reticulocyte lysate system. Late in infection, when most of the structural proteins are made, other DNA regions, not active at early times, give place to messenger RNAs.

The most important practical problem of ASF is that the sera from infected pigs, or from resistant animal species inoculated with ASF virus, do not neutralize the virus. To test the possibility that the resistance was due to the presence of antigenic variants in the virus population used as both immunogen and neutralization target, Vinuela et al. carried out a series of experiments with virus cloned by plaque purification in VERO cells. Again, a surviving fraction of 1 to 10 percent of the original virus was observed by using either immune serum or purified immunoglobulins, both in the presence of complement. When clones from the non-neutralized fraction were amplified and challenged with the above immune serum, the surviving value was the same as before. This suggested that viral particles in the surviving fraction were not genetic variants in the virus stock.

To test the possibility of a coexistence in the ASF virus antiserum of both neutralizing and blocking antibodies, Vinuela et al. prepared a collection of hybridomas which produce monoclonal antibodies (Mabs) against ASF virus. From a total of about 400 specific hybridomas, 90 have been cloned and stabilized and are being tested for virus neutralization. The monoclonal antibodies have also been useful for protein characterization and purification. Thus,

homogeneous protein vp73, used for diagnosis of ASF by an ELISA assay, has been obtained by immunochromatography.

Another important application of the Mabs obtained is virus typing. The virus passaged in tissue cultures was shown to be antigenically stable. However, different isolates from Africa, Europe, and America could be distinguished from each other by their relative affinity to a panel of Mabs.

Although it is clear that the critical target cells of ASF virus are the porcine monocytes and macrophages, there have been contradictory reports about the virus sensitivity of B- and T-lymphocytes. By using antibodies specific for membrane antigens of B- or T-lymphocytes and ASF virus, double fluorescence experiments showed no infection of either resting or mitogen-stimulated lymphocytes.

#### Research in Neurobiology

Regulation Phenomena in Neural Development. G. Ramirez and his coworkers have been studying neurotransmission in the developing chick visual system. They have used the retinotectal chick visual system in a developmental model in which two originally independent structures, the retina and the optic mesencephalon, become integrated into a functionally-defined system. Ramirez et al. established that cell-cell recognition and communication phenomena are of paramount importance in the coordination of these interactive processes. On the other hand, early visual functions might also influence the last stages of development as a whole. Therefore, Ramirez et al. explored the developmental profiles of some macromolecules involved in neurotransmission, looking for eventual modulatory effects of changes in the postnatal levels of visual input. They have shown that the chick central nervous system contains asymmetric collagen-tailed molecular forms of acetylcholinesterase (AChE), as is the case in peripheral cholinergic tissues. This finding was later generalized to other vertebrate species.

Ramirez et al. have found that there are two classes of collagen-tailed asymmetric forms (A-forms) of AChE not only in the retina but also in the brain, spinal cord, and skeletal muscle, where they play a role in nerve-muscle interactions. The collagen-tailed form of AChE constitutes 8 to 10 percent of the total retinal AChE activity. The class A-1 form of AChE was found to be linked to cell membranes exclusively by high ionic strength-sensitive forces while the class A-2 form appears to establish, additionally, tail membrane

bridges involving divalent cations, especially calcium. In skeletal muscle, class A-2 forms are predominantly extracellular and end-plate specific. Upon denervation, class A-1 forms are degraded faster and earlier than their class 2 counterparts. Ramirez et al. are investigating the physiological significance of the two forms of collagen-tailed AChE which appear to be associated with definite subcellular sites and are subject to contrasting mechanisms of neural regulation. They are also carrying out studies to assess the modulating influence of retinotectal interactions and postnatal visual experience on the different developmental profiles (characteristic for each molecular species) with special emphasis on the collagen-tailed forms of AChE.

Another study by Ramirez and his group is the characterization of the general properties and developmental profiles of specific binding sites for excitatory (putative) amino acid transmitters (L-glutamate, L-aspartate, kainic acid, and N-methyl-D-aspartate) in the chick optic tectum. Kainic acid appears to be a suitable ligand to label presumptive receptors in contrast with the very low binding values obtained with N-methyl-D-aspartate and the dubiously specific binding of L-glutamate and L-aspartate. Tectal kainic acid binding sites appear mainly after birth (i.e., eye opening). The density of membrane sites is modulated by visual input, at least during the first 3 weeks post-hatching. Monocular deprivation leads to higher receptor densities in the contralateral optic lobe while overstimulation produces the opposite effect. Thus, excitatory amino acid receptor distribution appears to play a part in the optimal adaptation of the individual to its visual environment.

These researchers are now also engaged in a similar project involving inhibitory amino acid transmitter receptors. Their ultimate goal is to establish the possible existence of some kind of developmental coordination between excitatory (permissive) and inhibitory (signal-blocking) synaptic mechanisms.

#### Developmental Interactions Between Schwann Cells and Peripheral Axons.

During the development of peripheral nerves several interactions occur between Schwann cells and axons that control the proliferation and differentiation of the cells. In myelin fibers, the axon seems to induce the production of myelin components by the Schwann cell. The asymmetric distribution of sodium channels localized primarily at the nodes of Ranvier is the main functional property of myelin fibers. Using

primary cultures of sensory neurons and Schwann cells that reproduce the morphological characteristics of peripheral nerves, Ramirez et al. are studying the role that Schwann cell-axon interactions could play in locating sodium channels at the nodes of Ranvier.

Monoclonal Antibodies Against Developmental Neural Antigens in *Drosophila Melanogaster*. Using the hybridoma technique, Ramirez and his group have selected 20 clones that produce monoclonal antibodies (Mabs) against the larval nervous system of the fruit fly, *Drosophila melanogaster*, an organism which is easily amenable to genetic manipulations. Because of the specificity of Mabs it is possible to select specific antigens from the larval nervous system and to identify the genes that code for them. The group plans to induce mutations in these genes in order to study their roles in the development of the nervous system of the fruit fly. Using immunocytochemical techniques, the group has recently identified enkephalin-immunoreactive neurons in the central nervous system of *Drosophila Melanogaster*.

Analysis of fly extracts by high-performance liquid chromatography and radioimmunoassay show a relatively complex pattern of immunoreactive compounds. The most prominent among them appears to be met-enkephalin. Enkephalins appear to act as neurotransmitters or neuromodulators in the neuronal system of numerous animal species, but not much information is available for invertebrates. Thus, the presence of enkephalin in *Drosophila Melanogaster* makes it possible to study peptide neurobiology in a relatively simple model system and to study the regulation of the expression of genes coding for these neuropeptides.

Genetics of Morphogenesis in *Drosophila*. G. Morata and colleagues are interested in determining the genetic components of the mechanisms governing the developmental processes of *Drosophila*. The general objective was approached from several different angles: (1) analysis of development of normal structures, in particular the cuticular derivatives; (2) study of genes which play a critical role in development, i.e., homeotic genes; (3) factors controlling cell proliferation during development; and (4) the genetic control of the development and function of the nervous system.

With respect to the analysis of normal development, Morata et al. have paid special attention to early development. A mosaic analysis of normal and mutant thoracic segments has shown that

they derive from the same number of cells. These and other results led to the hypothesis that all embryonic segments appear later in development as a result of the normal function of homeotic genes. Morata et al. have carried out the clonal analysis of the development of the head of the fly. They have found that the bristle pattern of different appendages is independent of lineage.

In the study of homeotic genes, Morata et al. have concentrated mainly on the genetic and developmental analysis of the genes of the bithorax complex. One particular locus, *bithorax*, has been studied in detail using all the extant viable alleles available in different genetic combinations and environmental conditions. Of the lethal alleles, those of *ultrabithorax* have been shown to contain several independent functions which work through a temporal sequence. The early function extends to the mesothoracic segment, hitherto considered to lack bithorax function completely. Because of this observation, Morata et al. have reexamined the role of the positional parameters on the activation of the genes, *bithorax* and *postbithorax*, concluding that they perform the same developmental function in different positions. Furthermore, for the genes *ultrabithorax* and *engrailed*, Morata et al. have shown that their activation depends exclusively on the position of the primordia and not on the identity of the structure into which the primordia normally developed.

Another study by Morata and his group is the control of proliferation. The mechanisms to maintain chromosomal integrity are essential for cell proliferation. Among these mechanisms are those in charge of DNA repair processes. Morata et al. have found evidence for an x-ray-inducible DNA repair mechanism in the *Drosophila* epidermal cells. After irradiation, the efficiency of the process is improved so that the number of cells that escape the repair process diminishes drastically. Mutations which interfere with this process result in a decrease of the efficiency of repair of chromosomal breakages and hence in an increase of aneuploid cells. Morata et al. had previously studied the viability of aneuploid cells in the epidermis. In general, one third of the small chromosomal deletions showed normal proliferation. Hyperdiploid cells, on the contrary, do not have a marked effect on viability, which diminishes linearly with the size of the hypodiploid fragment in hypodiploid cells. Another relevant factor in the control of cell proliferation is the phenomenon termed "cell

competition" by Morata's group. They have shown that cell competition is the result of local interactions between neighboring cells. These interactions only occur between cells of the same developmental system and are more pronounced the greater the difference in diversion rate of existing cells.

Morata et al. are also studying development and function of the nervous system in *Drosophila*. They have described the morphology of some structures that were poorly known, such as the sensory organs of the larva and the components in the escape-reaction circuit in the adult. They have also studied the cell lineage relationship among several cell types of different tissues including the hypoderm, the peripheral fat, the muscles, the alimentary canal, and the nervous system, both peripheral and central. In addition, they are studying the possible effect of certain homeotic genes like the Bx-c on the structure of the central nervous system. Previously, they had studied the effect of other morphogenetic mutations on adult structures.

Morata and his group have initiated a systematic search for antigens specific to neurons as a prerequisite for a genetic analysis of the development of the nervous system. At the present time, 200 Mabs have been isolated with varying patterns of tissue distribution. About half of them have been localized in protein gels. A subset of these proteins is under study in a search for the corresponding structural genes among several complementary DNA (cDNA) libraries.

With respect to the functional aspects, Morata et al. are studying the Shaker gene complex (Sh-c) that seems to be involved in potassium ( $K^+$ ) currents of the excitable membranes. A physiological study has shown that the Shaker mutations yield an abnormally long-lasting action potential. This effect can be mimicked in normal individuals by means of  $K^+$  current-blocking agents and is not affected in Shaker individuals by blocking of calcium currents.

**Antibiotics and Chemotherapeutic Agents.** A. Jimenez and colleagues are studying the expression of the Tn 601 (903) in the yeast *Saccharomyces cerevisiae*. This transposable element determines bacterial resistance to G418 and other aminoglycoside antibiotics. Yeast spheroplasts of a leu 2 strain were co-transformed with plasmid ColE1:Tn601 and the yeast cloning vector YEpl3. Several of the leucine prototrophs were resistant to the aminoglycoside antibiotic G410. From one of these transformants, a hybrid plasmid was isolated and further used to transform spheroplasts by selec-

ting for G418 resistance directly. Since G418 is active against most eukaryotic cells, it was proposed as a selective agent for dominant eukaryotic cloning vectors.

*Streptomyces hygroscopicus* produces hygromycin B and determines a phosphotransferase activity (mol. wt. 42,000) that inactivates this antibiotic. Hygromycin B is active against most prokaryotic and eukaryotic cells and could therefore serve as a new selective agent for eukaryotic cloning vectors. A 2.1 kb fragment from *Streptomyces hygroscopicus* DNA coding for the phosphotransferase (gene HG) was integrated in plasmid PIJ41 and has been cloned in *Streptomyces lividans*. Both the restriction and deletion map have been determined, and the gene HG has been allocated within a 1.1 kb ECOR1-BAMH1 DNA fragment and its sequence is being determined.

Jimenez et al. have found that *Streptomyces alboniger*, which produces puromycin, inactivates this antibiotic by acetylation. The enzyme uses acetyl-CoA as acetyl group donor. *Streptomyces alboniger* is also resistant to other aminoacylnucleoside antibiotics like blasticidin S and sparsomycin. However, the mechanism of resistance to these last two antibiotics seems to be different from that of puromycin since Jimenez et al. have not been able to observe any acetylation of blasticidine S in extracts of *Streptomyces alboniger*. DNA sequences that determine resistance to either puromycin or blasticidine S, independently, have been cloned from *Streptomyces alboniger* in *Streptomyces lividans*. In addition, DNA sequences that encode blasticidin S but not puromycin resistance have been cloned from *Streptomyces morookaensis*, a producer of blasticidine S in *Streptomyces lividans*. Jimenez et al. are analyzing the cloned DNA fragments in order to relate their structures as well as test their usefulness as selective agents for higher cell-cloning vectors.

Jimenez and his group are also studying the mode of action of several cytotoxic agents: anthelmecin, cyclopiazonic acid, bouvardin, axenomycin, grandilactones A and B, dihydroxydithy-onuplutine, and zaluzanin C (all of them inhibitors of eukaryotic protein synthesis) as well as imidine derivatives of 3-nitro-1,8-naphthalic acid (inhibitors of nucleic acid synthesis by intercalation within double-stranded DNA (dsDNA)). In addition, Jimenez et al. have isolated a new yeast mutant (strain Nar 2B) resistant to narciclasine and have studied its genetics as well as the binding parameters of ( $^3H$ )-narciclasine to the mutant 80S ribosomes. Recently,

they have also studied the quantitative binding of ( $^3\text{H}$ )-cryptopleurine to sensitive and resistant yeast ribosomes, finding that this alkaloid binds specifically to the 40s subunit in a 1:1 ratio.

#### Biology of Animal Virus Infection.

The infection of an animal cell by a virus normally leads to interference with cellular metabolism. For picornavirus (EMC virus and poliovirus), L. Carrasco and his colleagues have analyzed the effect of viral infection on a number of cellular parameters such as macromolecular synthesis, membrane permeability to several compounds, ionic content, membrane potential, ATP content, and amino acid transport. The possibility that viral infection inactivates an initiation factor necessary to translate capped messenger RNAs (mRNAs) was approached by double-infection systems. Carrasco et al. found that human cells double-infected with Semliki-Forest virus (SFV) and vesicular stomatitis virus (VSV) simultaneously translate the mRNAs from both viruses, indicating that SFV infection does not inactivate a cap-binding factor, as thought previously. The same thing happens with cells double-infected with poliovirus or EMC virus, plus SFV or VSV. The finding that capped mRNAs are translated in cells infected by picorna virus (EMC virus or polio virus) does not support the idea suggested by others that the shut-off of protein synthesis by poliovirus is based on the blockade of a cap-binding protein.

The Carrasco group has developed new systems for the assay and study of compounds with antiviral activity. The use of these systems has led to the identification of several new molecules with anti-herpes activity and almost devoid of toxicity both *in vitro* and *in vivo*. The mechanism of action and antiviral spectrum of these molecules is being analyzed. The group is also studying the action of another antiviral agent, interferon (IFN). IFN treatment of cells with human lymphoblastoid interferon inhibits the appearance of poliovirus proteins but does not prevent the shut-off of host protein synthesis by poliovirus. Analysis of the integrity of cellular ribosomal RNA (rRNA) and mRNA in IFN-treated cells indicates that they are intact and functional.

The action of IFN against herpes simplex virus (HSV-1) development was also investigated. No inhibition by IFN of viral macromolecular synthesis was observed, as assessed by biochemical and electron microscopy analysis. Though the number of full and empty HSV-1 virus equals those formed in control untreated cells, they are much less effective

(90-percent inhibition). Finally, the killing effect of NK cells on virus-infected HeLa cells and the action of IFN treatment was investigated. In agreement with previous findings, IFN treatment enhances the lytic activity of NK cells. In addition, Carrasco et al. have found that IFN-treatment of HSV-1-infected HeLa cells renders them ten times more susceptible to killing by NK cells. This effect is not observed in cells infected with adenovirus or vaccinia virus.

#### Additional Research Projects

Some of the other research projects at the Center of Molecular Biology are: (1) energetic homeostasis during the perinatal period and metabolic relationships during the lactogenic process (J.M. Medina); (2) regulation of aerobic glycolysis in normal and tumor cells (J. Carrascosa); (3) metabolic transport and molecular etiology of metabolic diseases (F. Major); (4) molecular pathology of amino acid metabolism etiology and pathogenesis of hyperglycemias (P. Garcia); (5) post-translational modification of mammalian brain proteins (R. Manso); (6) cell envelopes (D. Vasquez); (7) ribosome structure and function (F. Juan); (8) structure and function of proteins (M. Fernandez-Puentes); (9) replication and morphogenesis of bacteriophage  $\phi 29$  from *Bacillus subtilis* (J.M. Hermosa); (10) regulation of gene expression at the translational level in eukaryotic cells (J.M. Sierra); (11) hormonal regulation of gene expression (A. Niets); (12) microtubules (J. Avila); and (13) genetic variability of RNA viruses (E. Domingo).

#### Conclusion

The scientists at the Center of Molecular Biology, Canto Blanco (Madrid), Spain, are engaged in a wide variety of research projects in genetics, virology, cell biology, neurobiology, biochemistry, and microbiology. They have been making important contributions to the research in these fields. Also, the center plays a role in ongoing workshops/conferences in providing facilities for visiting scientists.

1/28/86

#### LIFE SCIENCES RESEARCH AT TRENT POLYTECHNIC, NOTTINGHAM, UK

by Claire Zomzely-Neurath.

#### Introduction

The emphasis of the training at Trent Polytechnic, both at the undergraduate and graduate levels is to

prepare students for positions in industry. The Department of Life Sciences has been expanded this past year, providing new laboratory accommodations for microbiology, plant physiology, and ecology. Furthermore, a section on sports administration and science emphasizing the physiology and biochemistry of stress was added to the teaching and research program in September, 1985. This area has been strengthened by the establishment of an exchange agreement between the sport physiology institute (Deutsche Sport Hochschule, Cologne, West Germany). The cooperative agreement allows for staff/student exchange visits as well as for the establishment of a joint research project.

The Department of Life Sciences receives extensive external support from industry for research projects as well as for post-doctoral fellows and research assistants. In part, because of the liaison between the department and industry, the graduates are able to obtain employment in spite of the high unemployment rate existing today in the UK. The academic staff of the department numbers 45 in addition to post-doctoral fellows.

There are 58 different research projects being carried out in the department in which the academic staff are actively involved. Four main areas form the research base in the department. These are: (1) herbicides, (2) microbial physiology, (3) biomedical pharmacology, and (4) ecology and comparative physiology.

#### Research Projects, Department of Life Sciences

Herbicides. The herbicide research group is studying herbicide action at several levels, including the influence of environment and formulation on herbicide efficacy, uptake, and translocation of both foliar- and soil-applied herbicide efficacy. The physico-chemical properties of leaf surfaces in relation to herbicides are also being investigated. In addition, a study of the ultrastructural and biochemical sites of action, herbicide selectivity, and resistance persistence is being undertaken. Furthermore, novel techniques using isolated cells and protoplasts are currently being developed to establish more precisely interactions of herbicides with plant cell biochemistry.

The group offers a consultancy service to the agricultural industry (soil analysis service) and contract work has continued throughout the year. Bee toxicity trials have been carried out for Hoechst and Bayer (UK) under the direction of L.B. Davies. Fungicide re-

sistance testing, especially with eye-spot disease of cereals and potato blight has formed a major part of work undertaken in the current year. In this respect, tests have been carried out on behalf of Agrisearch Ltd. and Dupont (UK). Soil analyses have formed a rather minor part of the services this year with tests being carried out for Youngplants Ltd., Monsanto Ltd., Agrisearch Ltd., and the Dow Chemical Company.

Microbial Physiology. Projects in the general area of microbial physiology include the biochemistry and the physiology of cyclohexane-degrading organisms, the biochemistry and physiology of microorganisms degrading xenobiotic compounds, the interaction of mixed microbial populations in the treatment of recalcitrant chemical wastes, and the production of  $\alpha$ -amylase by bacteria. In addition, there is strong supporting work in the physiology and metabolism of yeasts, the microbial physiology of metal corrosion, the microbial genetics of radiation resistance and thermophiles, and some areas of immunomicrobiology.

Collaborative and financial support comes from many outside sources including Imperial Chemical Industries, the Admiralty at Portsmouth, and Leicester University Biocentre. In the past year the Department of Life Sciences has attracted substantial funds from both private industry and the major UK research centers and councils to support biotechnological aspects of the microbial physiology research group. For example, \$85,000 was given by ICI Petrochemicals to study the potential of cycloalkane-degrading microorganisms as biocatalysts in the petrochemical industries and \$35,000 from the Water Research Centre to study the microbial degradation of xenobiotic organohalogenes. Such financial commitment is an indication of the potential commercial application of this work.

Biochemical Pharmacology. Research in this area is concentrated on the study of the biochemistry of calcium-mediated-stimulus secretion coupling. This work is centered on the importance of certain calcium-activating enzymes that may be involved in the membrane-mediated events during insulin secretion from the islets of Langerhans of the pancreas. The pharmacological application of these studies has implications for the treatment of diabetes. Thus, this area has attracted substantial funding from a variety of sources with half the funds allocated to increase the research personnel in this area.

Ecology and Comparative Physiology. Research in applied aspects of this area



covers several projects of both local and international interest. The ecology of Creswell Craigs and Rufford Park (local tourist attractions) is being investigated, particularly the effects of saline mine effluents on freshwater fauna. The role of water quality factors, hardness and pH, which modify heavy metal toxicity to fish is being studied. Severn-Trent Water Authority is supporting work on the reproductive physiology of coarse fish to improve aquaculture techniques. The Central Electricity Research Laboratories are collaborating in research on the effects of acid fresh waters on upland amphibian populations. Aspects of arctic ecology are currently being investigated.

While most of the research falls into these broad classifications, there is significant work in the fields of clinical biochemistry, neurophysiology,

and exercise physiology. A list of the research projects for 1985 is shown in Table 1.

#### Conclusion

The fairly small and relatively new Department of Life Sciences at Trent Polytechnic is engaged in a wide variety of research projects at the basic and applied levels. The importance of the research in the applied area is attested to by substantial financial support from industry and government research councils. The liaison with industry serves an important role in bringing the results of laboratory research into the commercial market.

2/3/86

Table 1

#### Research Projects in the Department of Life Sciences Trent Polytechnic, 1985

##### Calcium Metabolism

Calcium Antagonists and Smooth Muscle, R.F.L. Bates.

The Role of Transglutaminase in Calcium-Mediated-Stimulus Secretion Coupling, M. Griffin.

The Mechanisms of the Central and Peripheral Actions of Calcitonin, R.F.L. Bates.

##### Mammalian Systems

An Investigation of Muscle Fatigue in Human Subjects, G. Compton.

Neurotransmitter Uptake Mechanisms in Mammalian Central Nervous System, S.E. Mireylees.

The Metabolism and Excretion of Drugs by Liver and Kidney at Extremes of Age and in Diseased States, R.F.L. Bates, S.E. Mireylees.

Studies on the Physiology of Coordination During Physical Activity, G.J. Compton.

The Role of Transglutaminase in Tumor Growth and Metastasis, M. Griffin.

Red Cell and Plasma Enzymes in Megaloblastic Erythropoiesis, T. Palmer.

Biochemical Mechanisms Involved in Pulmonary Interstitial Fibrosis, M. Griffin.

Intracellular Aspects of Urea Cycle Lysine and Ornithine Metabolism, T. Palmer.

Monoamine Uptake in Mammalian Brain, S.E. Mireylees.

Melanocyte-Stimulating Hormones in the Mammal, R.G. Pye.

The Role of Neutrophil Secondary Granules in Inflammation; Modulation of Lymphocytic Responses, P.C. Blaxhall.

##### Plants

Plant Growth in Peat Media Amended with Calcined Clay, W.R. Carlile.

The Mobilization of Storage Proteins in Germinating *Vicia Faba*, R. Olsson.

Physiological Studies of Herbicides, L.G. Davies.

The Mode of Action of Leaching Herbicides, K.E. Pallett.

Stomatal Physiology and its Control in *in vitro* Cultured Plantlets, K.C. Short.

Non-Photosynthetic Interaction of the Herbicide Bentazone with Plant Growth and Development, A.H. Cobb.

The Influence of Bentazone on Stomatal Movement, A.H. Cobb.

The Effect of Herbicides on Plant Growth and Development (Trifluralin With Sugar Beet), L.G. Davies.

Ecology of Spoil Tips and Ecological Effects of Air Pollutants, P.B. Pyatt.

An Investigation into the Mode of Action of Fluroxypyr 4-Amino-3, 5-dichloro-6-fluoro-2-pyridyloxyacetic Acid in Selected Weed Species, K.E. Pallett.

*In Vitro* Propagation and Selection for Sodium Chloride Tolerance in Chrysanthemums, K.C. Short.

Metabolic Studies of Chloroplast Symbiosis, A.H. Cobb.

Biochemical Indications of Crisping and Storage Qualities of Potatoes Subject to Differential Agronomic Regimes, T.G. Vickers.

Selection and Mutagenesis in Cultured Haploid African Violet Plants, K.C. Short.

##### Microorganisms

Isolation and Analysis of Mutants of *E. Coli* Hyper-Resistant to a Number of DNA-Damaging Agents, S.I. Ahmad.

Metabolism of Xenobiotic Chemicals by Bacteria, A. Smith.



Table 1 (Cont'd)

Control of Helminths in Farm and Sewage Wastes, C. Terrell-Nield.  
 Studies on Bacterial Dehalogenases, A.J. Skinner.  
 A Study of Cyclohexane-Degrading Micro-Organisms as Potential Industrial Biocatalysts, S.I. Ahmad.  
 A Biochemical and Immunological Investigation of The Polysaccharides Produced from Sugars by Oral Streptococci, S. Hammonds.  
 A Study of the Mechanisms Involved in Fuel Organism Corrosion of Metals, T.G. Cartledge.  
 Production of  $\alpha$ -Amylase by Bacterial Fermentation, A. Smith.  
 Biological Conversion of L-Aspartic Acid and L-Phenylalanine Methyl ester to the Artificial Sweetener Aspartane, S.I. Ahmed.  
 Ecology of Alpine and Near Arctic Areas, F.B. Pyatt.  
 Characterization of Metabolic Activity in Cells Isolated from Glycine Max and Triticum Aestivum, K.E. Pallett.  
 The British Distribution and Feeding Ecology of Pterostichus Madidus (F) (Col. Carabidae), C. Terrell-Nield.  
 An Investigation into the Mode of Action and Selectivity of Clopyralid, K.E. Pallett.  
 Enzymic Oxidation of Cycloalkanes, M. Griffin.  
 The Microbial Metabolism of Cycloalkanes and its Application to the Enzymic Synthesis of Important Cyclic Terpene Alcohols, M. Griffin.

#### Marine Biology

An Eco-Physiological Study of the Effects of Acid Rain on Amphibia, N.A. Macfarlane.  
 The Separation, Characterization and Transformation of Fish Lymphocytes, P.C. Blaxhall.  
 Interaction of Water Quality with Pollutant Toxicity in Brown Trout (*Salmo Trutta*), N.A. Macfarlane.  
 Studies on Mechanisms of Ion and Water Exchange in Teleostan Fish, N.A. Macfarlane.  
 Effects of Acid Precipitation on the Ecology of Terrestrial Epiphytes, Freshwater Phytoplankton, and Invertebrates; Long-Term Anthropogenic Considerations, F.B. Pyatt.

#### Insects

Physiological Investigations into Control Systems Regulating Posture and Locomotion in Stick Insects, D.H. Godden.  
 The Effects of Insecticides on the Locust Central Nervous System, D. Godden.

## Computer Sciences

### ARTIFICIAL INTELLIGENCE AT MILAN

*by Paul Roman. Dr. Roman is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on assignment until September 1987.*

The high-technology center of Italy, the ancient-yet-modern city of Milan, is the home of much of the artificial intelligence (AI) research and development in Italy. Recently I visited three of the foremost centers of activities in this field: the AI Section of the Department of Electronics at the Polytechnic University, the Systems and Software Project Division of the general-purpose research institute CISE, and the Robotics and Industrial Automation Division of FIAR, a private industrial company. The research areas that I identified as particularly important and with possible interest to the US Navy are as follows:

- Unified formal theory of problem solving (especially design of a universal problem solver)
- Representation of procedural knowledge in expert systems and applications to process control
- Decision support in process environments via an expert systems (ES) approach
- Real-time knowledge-based systems operating in a multi-sensor environment (i.e., sensor fusion, input interpretation, multiple input reasoning).

In this article I will give a brief review of each institute's profile and describe, in somewhat more detail, a few selected projects.

#### The AI Project Group at the Milan Polytechnic

This research group, operating within the framework of the Department of Electronics, was started as early as 1971 by Professor M. Somalvico, its founding director. Both theoretical and experimental work in AI, robotics, and related areas are within the scope of the group, which currently consists of 10 faculty members, several visiting scientists, and about 18 graduate students. Current research areas are:

- Theory of problem solving
- Development of expert systems

- Knowledge representation
- High-level programming languages, including manipulation languages and special languages for vision
- Natural languages for data base construction
- Program synthesis
- Construction of 3D object models
- Integrated manufacturing systems, including sensor systems.

Perhaps the leading theoretical effort is in the area of problem solving. The researchers went a long way to develop a unified formal theory, which is comprehensive compared with the various approaches tried in many centers. The theoretical foundations of both the state-space and the problem-reduction approaches have been clearly defined, and a unified approach for embedding both the syntactic and the semantic aspects involved in problem solving has been formulated. A particularly successful research line studied the automatic change of problem representation in problem solving. A new method has been presented which faces the goal of changing the problem representation by considering a new scenario, called multi-problem solving. In this approach a given problem representation is split into a variety of mutually related problems on which a comprehensive problem solution search process is conducted. The architecture of a multi-problem solving system has been defined and its functions have been investigated and described in an algorithmic way.

In a related area, program synthesis, Somalvico, F. Caio, and G. Guida presented a novel conceptual and methodological approach, called bidirectional synthesis. Their approach bases the automatic programming on problem reduction (a top-down activity) and a structured binding together of program modules (a bottom-up activity). This approach is experimentally supported by the development of the bidirectional synthesizer (BIS) system for interactive synthesis of LISP programs. BIS was written in LISP and is devoted to the synthesis of programs in the area of list manipulation, and sorting and merging algorithms.

Currently, projected research in program solving considers the development of a universal problem solver. This system is meant to take in "states" from different data bases and use an auxiliary expert system (ES) to instruct the central knowledge-based system regarding the correct interpretation of the input and the applicability of appropriate rules. The idea is represented schematically in Figure 1. DB means data base;

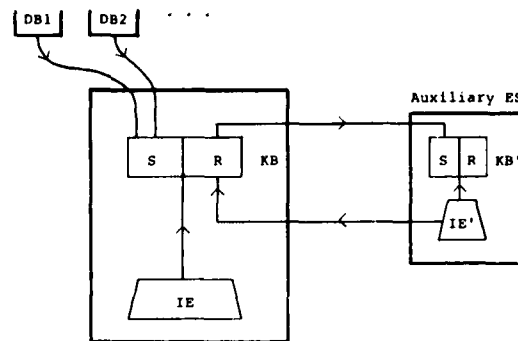


Figure 1. Scheme of universal problem solver.

KB refers to knowledge base, IE to inference engine. S stands for states, R for rules.

Regarding the other research areas of Somalvico's group, I can provide, on request, brief summaries of each. I would like to conclude this section by describing briefly the exciting demonstration of a vision-machine system that I witnessed. The sensory input is provided by a charge-coupled device (CCD) camera. One routine in the program accomplishes gray-level distinction. After automatic computation of the best cutoff (which can be overridden by the user), another routine converts this representation into a pixel-picture. Further routines can then analyze contours, determine geometric characteristics, make calculations, and perform desired image transformations. The operation, actively controlled by a menu, is almost real-time.

#### AI Research Highlights at CISE

CISE, short for Centro Informazioni, Studi, Esperienze (Center for Informations, Studies, and Experiments) is a private R&D company involved in many diverse high-tech activities. (A more detailed profile of CISE is given on page 139 in my article on electro-optics and laser research at CISE.) The Systems and Software Projects section is headed by Dr. A. Stefanini; it has six academic members, two technicians, and several students. ES is one of the group's central activities. This program is only three years old and is financed to a great extent by the Italian Electricity Agency (ENEL). Consequently, much of the actual design work is on areas of interest to the electricity industry such as a prototype implementation of an ES assistant to the operator of a power plant, of an ES configurator for telecontrol units, and for

ES diagnostic tools for turbogenerators (the last one is specifically designed for the Italian Committee for Nuclear and Alternative Energies [ENEA]). However, very understandably and laudably, these contract-assignments allow for the financing of fundamental theoretical investigations. I will briefly summarize two.

The first recent study, conducted by Stefanini and M. Gallanti, in cooperation with colleagues from other institutions, considers the problem of representing procedural knowledge in ES and the relevance of this to process control systems. A novel ES architecture has been designed which supports explicit representation and effective use of both declarative and procedural knowledge. These two types of expert knowledge are represented by means of production rules and event graphs respectively, and they are processed by a unified inference engine. Communication between the rule level and the event-graph level is based on a full visibility of each level on the internal state of the other, and it is structured in such a way as to allow each level to exert control on the other. The basic architecture is schematically represented in Figure 2.

This structure offers several advantages over more traditional architectures. Knowledge representation is more natural and transparent; knowledge acquisition turns out to be easier since pieces of knowledge can be immediately represented without the need of complex transformation and restructuring; inference is more effective due to reduced non-determinism resulting from explicit representation of fragments of procedural knowledge in event-graphs; finally, explanations are more natural and understandable.

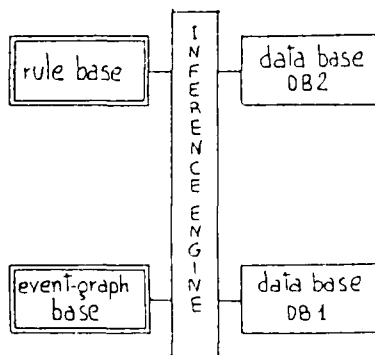


Figure 2. Basic system architecture of the CISE system.

The second current research I will briefly summarize is essentially an adoption of the above-proposed architecture for the design of intelligent decision support aids in process environments. A study by Gallanti and Guida (from the Politecnico) first introduces the basic concepts about a process environment and discusses its main features. The fundamental points of ES technology are then briefly illustrated, focusing on design and application issues. The impact of this newly emerging technique on the design of intelligent decision support systems for process environment applications is then analyzed, and a brief state-of-the-art is presented. A case study concerning the design and implementation of the so-called PROP ES for operator support in monitoring the pollution of cycle water in a thermal power plant is reported and discussed in detail. The paper concludes with an assessment of the difficulties of this new application area and an analysis of the challenges it poses to artificial intelligence research.

Although it would lead us too far to go into details, I find it useful to at least show, in Figure 3, the general architecture of PROP.

#### AI Work at FIAR

FIAR (Fabbrica Italiana Apparecchiature Radioelettriche SpA, "Italian Factory of Radioelectric Appliances"—a historically motivated name) is a medium-sized private company, engaged both in R&D and manufacturing. Most of its products are designed for the military market. (A more detailed characterization of FIAR will be given in a subsequent *ESN* article on FIAR's work in laser rangefinders.)

Following are some interesting items I learned during my recent visit to FIAR's Automation and Robotics Division, which is directed by Professor S. Rossignoli, assisted ably by Dr. I. Braga, who actually was my host.

The division has three major areas: robotics, sensors, and AI. Even though it is not in my field of coverage, I perhaps should mention that the Robotics Section has developed a widely used intelligent robot for industrial assembly which is capable of "fine motion" execution. It can be adapted for a robomobile service and for performing actions inside a satellite. A new generation of these devices will become commercially available in 1986. These systems will use the 32-bit family microprocessor of Motorola.

The Sensor Section has developed an advanced vision system in conjunction with their robot systems. (A brochure is

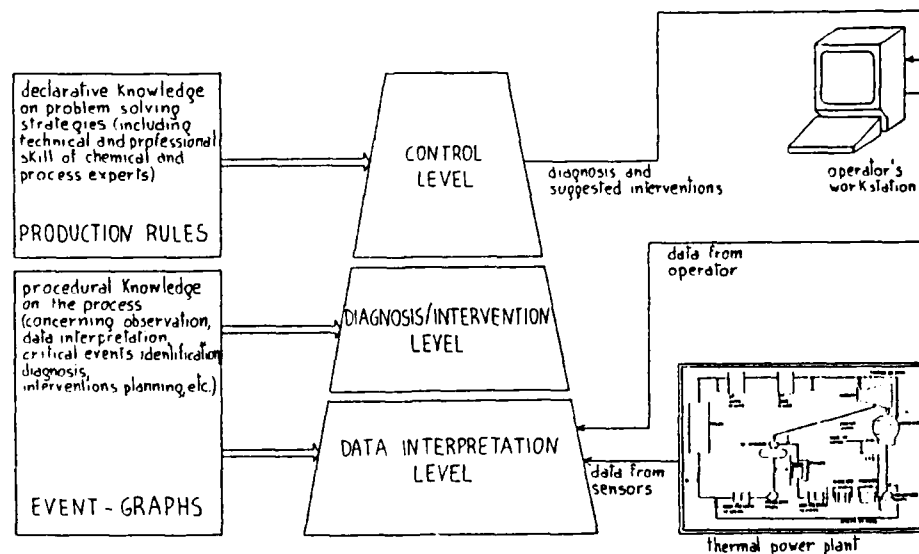


Figure 3. General architecture of PROP.

available from me upon request.) Their current plans involve the construction of a comprehensive, intelligent vision system (governed by a built-in ES). Since different subsystems have already been developed by FIAR, the researchers expect to have a prototype available by 1987. In the still further future the Sensor Section will develop a complete instrumented remote-control system which will combine optical, acoustical, and tactile sensor inputs and intelligent adaptive control features. It may be worthwhile to note that processed sensory signals will be connected to the electronics by optical fibers.

Now I come to the items I was most interested in, the work of the AI section proper; this focuses on ES work. The star project is the design and development of a sensor fusion system; i.e., the evolution of cooperating real-time knowledge-based systems operating in a multi-sensory environment. This project was commissioned by the New Technologies Subgroup of the Independent European Programs Group. While this group is associated with NATO, it is not directed by it. FIAR is the designated leading agency for the sensor fusion program, and a French, a Belgian, a Dutch, and 4 British firms cooperate. The immediate aim of the project is to lead to an essentially real-time knowledge-based system (RTKBS) for use in battle management. Currently, fusion of sensory data for terrestrial and aerial operations is envisaged; the immediate

goal is the development of a general system (capable of several seconds reaction time at a distance-coverage range of 100 meters, or a somewhat longer reaction time for panoramic surveillance at the over 10-km range). Each nation would then adapt the general design to its special needs. It is obvious that the fusion and intelligent, automatic real-time evaluation of sensory data obtained from visual, laser, acoustic, radar, microwave, infrared sensor and imager, as well as other possible inputs is also of outstanding importance in extended naval battle management operations.

Professor Somalvico of the Polytechnic (see above) is the chief academic consultant to FIAR on the sensor fusion project. He and Braga explained to me that the project will provide three different yet cooperating types of inferential activities: understanding, reasoning, and monitoring. Particular emphasis will be given to the areas of RTKBS and problem solving, together with the problems caused by noisy, fuzzy, uncertain, incomplete, and contradictory knowledge.

The general architecture of the overall system is represented by Figure 4. The sensory systems feed into a more-or-less conventional computer-based signal processing unit which has some limited intelligence and makes a rough evaluation of each set of data. It may request additional inputs if needed. The processed data then enter the expert

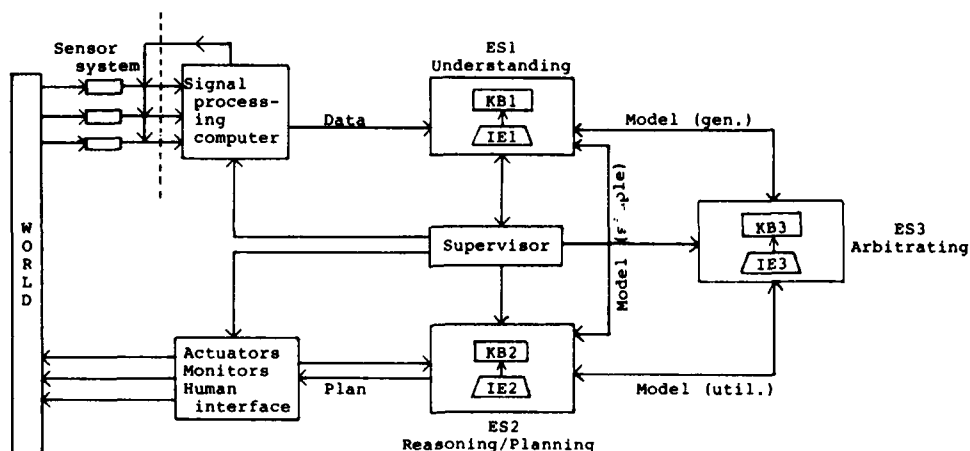


Figure 4. General architecture of the sensor fusion system.

system ES1, which tries to understand the meaning of the data-complex. It consists of the knowledge base KB1 and the inference engine IE1. Here, KB1 contains models and IE1 tries to match the available information with one of the models. In case of a simple outcome of the process, ES1 reports back to the signal processor so as to aid it in further processing (while no substantial changes in the world arise). More importantly, in these simple situations ES1 passes on its chosen model directly to ES2, which is an expert system charged with the task of reasoning and planning. Its knowledge base KB2 has models for drawing conclusions on the situation of the world and models of planning actions to actuate changes. The inference engine IE2 then produces a plan of action which it passes on to a set of actuators and monitors. It is important to understand that this unit is meant to include the human operator (call him "pilot"). The actuator unit can go back to ES2 if additional or alternative plans of actions are required. Finally, the actuators effect the action on the external world as needed (aiming and firing a gun, or even changing the setup and functioning of the sensory system).

If the understanding process accomplished in ES1 is not leading to a simple picture (for example, if conflicting models are reached), the general model(s) are passed on, not to ES2, but to another, special-purpose expert system, ES3, which plays the role of an arbitrator. After a possible further dialog with ES1, it communicates the model to be utilized (the "right" model) to ES2. This reasoning unit, in turn, may ask ES3 for additional arbitration, includ-

ing decisions in regard to alternative plans devised by IE2.

Finally, the system contains a central supervisor unit. Its role is simply to synchronize the performance of all other units; i.e., it acts as an intelligent clock.

The design project is in an early stage. For example, no decision has yet been made on whether KB1 will use object-attribute techniques or rules-frames devices. In any case, there is great excitement prevailing in FIAR.

#### Conclusion

Even though I saw only the surface of AI activities in Milan, I feel confident to say that we have here a lively, historically well-based, ambitious group of capable researchers. While much of the work is definitely industry oriented, there is sufficient basic research to keep the future safe. I also found the university/research-centers/private-industry cooperation commendable.

2/2/86

## Material Sciences

### CERAMIC MATRIX COMPOSITES

by Kenneth D. Challenger. Dr. Challenger is the Liaison Scientist for Materials Science in Europe and the Middle East

for the Office of Naval Research's London Branch Office. He is on leave until May 1986 from the Naval Postgraduate School, where he is Associate Professor of Materials Science.

### Introduction

EUROMECH 204 was held in Jablonna (near Warsaw), Poland, 11 through 15 November 1985. The topic of this colloquium was the fracture of brittle matrix composites. Several excellent papers were presented on the micromechanical mechanisms of fracture and on analytical methods to predict fracture in fiber-reinforced brittle matrices where the matrices included various ceramics, epoxies, and concretes. The papers on composite ceramics that are reviewed in this article are particularly noteworthy because of their relevance to the US Navy's needs.

The colloquium was organized by Professor A.M. Brandt, Polish Academy of Sciences, Institute of Fundamental Technological Research, Warsaw. Most of the 55 participants were from Eastern Europe, but Sweden, France, The Netherlands, and West Germany also had many participants. I was the only US citizen present.

The full colloquium proceedings will be available from Elsevier Applied Science Publishers in May of 1986.

### Composite Ceramics

Researchers at the Max-Planck-Institut für Metallforschung, Institut für Werkstoffwissenschaften, Stuttgart, West Germany, (Professor H. Fischmeister, director), are very active in the development of composite ceramic materials. They form one of the leading ceramic research teams in Europe. T. Haug and R.F. Pabst described their attempts to apply the principles of fracture mechanics to the characterization of the strength of multi-phase composite ceramics, SiC + Si and SiO<sub>2</sub> + Al<sub>2</sub>O<sub>3</sub>. These multiphase materials contain a viscoelastic glassy phase at the testing temperatures; consequently, the fracture toughness is a function of temperature and loading rate. The short cracks are normally intergranular and do not grow self-similarly, but change shape significantly as they grow. Hence, a fracture mechanics approach was not feasible and the method for solutions remains an open question. [Note: The distinction between short and long cracks is somewhat subjective. For this discussion, a short crack is one where the crack dimensions are on the order of, or less than, the dimensions of the microstructure; i.e., grain size.] Long cracks in these mate-

rials tended to be bridged behind the crack tip by the viscoelastic phase, but self-similar crack growth was observed. This bridging by the viscoelastic phase acts like an adhesive, creating a traction force on the crack surface. Haug and Pabst showed that fracture mechanics can accurately predict the behavior of long cracks once this traction force is accommodated in the calculation of the stress intensity factors.

S. Lauf (another member of Pabst's group) reported that if the glassy phase (SiC-Si) is in a brittle form and the cyclic loading frequency is less than 2 Hz then the fatigue life can be computed from static tests. However, at elevated temperatures and higher frequencies, both the loading rate and oxidation will affect the growth rate of the crack, and time-dependent effects must be included in the prediction of fatigue life.

K. Kromp (Pabst's group) found that the creep growth of a 7×3.5×0.35-mm three-point bend specimens tested at 1350°C (SiC-13 volume percent Si) was linearly elastic if the loading rate was either very low (~0.05 µm/min) or very high (~5 µm/min). However, at intermediate strain rates the deformation of the glassy second phase was activated, and a non-linear, plastic load-displacement behavior was observed.

R. Lundberg, R. Pompe, and R. Carlsson (Swedish Institute for Silicate Research, Göteborg, Sweden) have evaluated the effect of various processing methods on the strength and fracture toughness of several different fiber reinforced Si<sub>3</sub>N<sub>4</sub> ceramics. They have tested C and Al<sub>2</sub>O<sub>3</sub> fiber and SiC-wisker reinforced Si<sub>3</sub>N<sub>4</sub> (containing 0.2 percent Al<sub>2</sub>O<sub>3</sub> and 0.6 percent Y<sub>2</sub>O<sub>3</sub> as sintering aids) made by three different processes: reaction bonding, pressureless sintering, and hot isostatic pressing (HIP). The carbon fibers were found to chemically react with the Si<sub>3</sub>N<sub>4</sub> during sintering. These reactions result in gaseous products that prevent bonding between the fiber and the matrix. However, hot isostatic pressing can suppress these reactions and produce a useable material. The Al<sub>2</sub>O<sub>3</sub> fibers were completely dissolved by chemical reactions during sintering and thus cannot be used to reinforce Si<sub>3</sub>N<sub>4</sub>. The SiC whisker (0.3-µm diameter × 30-µm length) reinforced material is by far the best of these three materials. It could be made successfully by all three manufacturing methods. The pressureless sintered material has a fracture toughness, K<sub>IC</sub>, of about 7 MNm<sup>-3/2</sup> and a bend strength of 370 MPa. The hot isostatically pressed material is expected to

be even better than this, but has not been tested yet.

Professor Pampach, Institute of Materials Science, Academy of Mining and Metallurgy, Cracow, presented the results of his experiments investigating the chemical reactions between carbon fibers and Si, Al, and Ti matrices. The influence of these reactions on the strength of the fiber was measured. Single carbon fibers were coated with about 1  $\mu\text{m}$  of Al and Ti by vapor phase deposition and with SiC by chemical vapor deposition. The coated fibers were heated to 1270°K for various lengths of time, thereby creating a range of reaction zone thicknesses. These fibers were then tensile tested to failure and the effect of the various reaction layers on strength determined. Two critical thicknesses of the brittle zone were found to exist. The first critical thickness ( $\sim 0.1 \mu\text{m}$ ) marks the transition from a condition where the strength is controlled completely by the fiber to a condition where the strength begins to decrease due to the brittle layer. From this thickness up to about 0.6  $\mu\text{m}$ , the strength continually decreases as the reaction zone thickness increases, but beyond this thickness, the strength is completely controlled by the reaction zone and thus remains constant and independent of the reaction layer thickness. The growth of this reaction zone is parabolic with time and, after the rate constants for the parabolic relationship were established, short time tests were successfully used to evaluate the effects of longer reaction times.

Professor K. Herrmann (University of Paderborn, West Germany) presented a model that he has developed for the fracture of fiber-reinforced brittle matrices. Experimentally, he used a model system consisting of an Araldite F matrix with steel fibers. Finite element and photoelastic methods have been used to generate the data used to develop this model. Cracking in his experiments was created by well-defined, imposed thermal stress fields. A modified crack closure integral is used to determine the strain energy release rate at the crack tip for both matrix and interface cracks. This model has been shown to be capable of predicting the curved cracking path that has been observed in this self-stressed two-phase composite. This is a remarkable accomplishment; therefore I believe that his work is worthy of continued attention. Anyone interested in more details of his model should either contact Herrmann directly or me.

#### Metal-to-Ceramic Bonding

Researchers M. Turwitt, G. Elsner, and G. Petzow of the Max-Planck-Institute (MPI), Stuttgart, are studying the fracture behavior of metal-to-ceramic joints. This is an important topic because the requirements for this type of bonding are certain to increase as ceramics find more widespread industrial usage.

The specimens used for their studies are solid state bonded four-point bend test specimens incorporating  $\text{Al}_2\text{O}_3/\text{Nb}/\text{Al}_2\text{O}_3$  joints which are notched at one interface. The bond strength was characterized by the interface fracture load and a geometric correction function, which depends on the geometry of the specimen and the elastic constants of the bonded materials. Nb 1 mm thick was pressure bonded (10 N/mm<sup>2</sup>) to the  $\text{Al}_2\text{O}_3$  at 1700°C in a vacuum for two hours. By this technique, both polycrystalline and single crystal  $\text{Al}_2\text{O}_3$  were bonded to Nb.

Two different types of interface fracture occur: pure interface fracture where the critical crack propagates exactly along the Nb/ $\text{Al}_2\text{O}_3$  interface, and a mixed interface propagation. The interface fracture energy,  $G_c$ , based on a global energy balance for the creation of new surfaces, was found to be a good parameter to characterize the bond strength.  $G_c$  is affected by microcracks (caused by a thermal expansion mismatch), by impurities or reaction layer phases at the interface, by unbonded areas, and by the grain size of the  $\text{Al}_2\text{O}_3$ . The single crystal  $\text{Al}_2\text{O}_3/\text{Nb}$  interface fracture energy was a function of the crystallographic orientation of the  $\text{Al}_2\text{O}_3$  ( $G_c$  ranged from 74 J/m<sup>2</sup> to 150 J/m<sup>2</sup> for the different orientations). The researchers believe that this could be caused by differences in the atomic structure at the interface or by orientation-dependent energy dissipation processes, or by both. Excellent lattice imaging transmission electron microscopy was performed at the single crystal  $\text{Al}_2\text{O}_3/\text{Nb}$  interface, confirming that no reaction region exists at this interface. However, even standard optical microscopy revealed a reaction layer at the polycrystalline  $\text{Al}_2\text{O}_3/\text{Nb}$  interface; no explanation for these differences was given.

This research is of high quality and very relevant to the problems associated with bonding ceramics to metals.

#### General Impressions

Several items of general interest arose during the colloquium. First, the Polish institutes that are supported by

the Academy of Sciences were scheduled to undergo a change in January, 1986. At present, and since these institutes began, the Director of an academy institute has guaranteed funding and a free hand in selecting what topics to study. This will change in January. I do not know exactly what changes will occur, but the Directors of these institutes know that they will have to find other sources of support for some of their research. It also appears that the government will play a more active role in determining the topics to be studied. In the opinion of many of the Poles at the colloquium, heavy industries, such as coal mining and steel making, will be favored. This may not be exactly true, however, because Professor R. Pampuch (Institute of Materials Science, Academy of Mining and Metallurgy, Cracow) mentioned that a new program on the development of engineering ceramics, with emphasis on ceramic composites, will begin at his institute next year. According to him, this will be a very large program (I could not determine what he means by very large).

Another item of interest is that Polish scientists who are active in ceramics and concrete research collaborate to a large extent with French and Dutch scientists.

Two future meetings were announced: "Mechanics of Polymer Composites," Prague, Czechoslovakia, April, 1986, and "Adhesion Between Polymers and Concrete," Aix en Provence, France, 16 through 19 September 1986.

West Germany appears to be the European leader in the development of engineering ceramics. The Max-Planck-Institute for Metal Research, Stuttgart, and Metals Research Institute of the German Aerospace Research Establishment, Cologne, both have large programs and excellent scientists/engineers focused on the development of these materials.

Kenneth D. Challenger  
12/6/85

## Mechanics

### FLUID MECHANICS, COMBUSTION, AND HYDROACOUSTICS AT BERTIN

by Eugene F. Brown. Dr. Brown is the Liaison Scientist for Fluid Mechanics in

Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1987, from the Virginia Polytechnic Institute and State University, where he is a Professor of Mechanical Engineering.

The headquarters of Bertin and Co. is in Plaisir, France, a suburban community located approximately 20 miles southwest of Paris. It is a private research and development organization which specializes in the automation, control, energy, structural mechanics, fluid mechanics, and industrial process areas. Approximately 30 percent of its income comes from contracts with the French Ministry of Defense, and the remainder comes from high technology nationalized industries in the energy and defense-related areas. The company does little by way of basic research and prefers to rely on the acquisition, modification, and utilization of existing technologies in their technical work.

### Fluid Mechanics

Bertin's fluid mechanics activities are centered in the Fluid Mechanics and Structures Division headed by Jacques Souquet. My visit was hosted by Yves Brocard, the associate director of the division. The division consists of approximately 25 people, 18 of whom are graduate engineers. They have a Prime 850 mainframe computer and a link with the CRAY-1 at the University of Palaiseau. They will soon have a link with a CRAY at ONERA.

Their principal experimental facility is a low-turbulence water tunnel with capabilities of up to 400 liters per second and various test sections up to a maximum of 40x40 cm and flow velocities from 4.5 to 15 m/s. It is suitable for force measurements and LDV measurements. Hydroacoustic studies between 40 Hz and several kHz are possible. They also own a 3-m diameter circular towing tank.

Approximately 50 percent of their Ministry of Defense work is done for the French Navy for whom, in addition to fluid mechanics studies, they have worked on vibration and materials problems. They have developed light, composite hulls for light anti-submarine (air- and ship-launched) torpedos. They have also worked in the area of fusing; however, much of this work is proprietary and, therefore, no discussion of substance took place on this topic.

Another interesting application of composite materials was their fiberglass frame for towing acoustic detectors



(sonars) for surveillance and minesweeping operations. The frame features fully contoured airfoil sections which allow greater (negative) lifting forces to be generated than with conventional vane-type airfoil sections. This, combined with the intrinsic lightness of the fiberglass material, results in a structure which is smaller and from four to five times lighter than competing designs. This product contains both high-technology hydrodynamics and high-technology materials. Such an advanced design, they claimed, was possible only because of their multi-disciplinary nature which enables them to produce designs which represent optimal combinations of several technologies.

The division's work in computational fluid dynamics seems to be relatively conventional. In the spirit of the company, they have made good use of the literature, often adapting (sometimes with substantial modifications) computer programs purchased from the United States. They have also written their own programs based on information contained in the literature. As a result, they have lifting line and lifting surface programs, programs for predicting slipstream/wing interactions (using both actuator disc and vortex particle methods), and coupled viscous/potential flow programs for predicting airfoil and compressor stall.

They have their own parabolized Navier-Stokes (PNS) code and have applied it to optimizing the geometry of a steam-driven air ejector. Their interest was in designing the shortest shock- and separation-free diffusing section. Their design was not only shock- and separation-free but exhibited a wall pressure distribution which agreed quite respectably with the theoretical predictions.

Their full Navier-Stokes (FNS) code represents their most recent computational activity. The program which they are using is a descendant of the YAQUI program, which they obtained from the Los Alamos Scientific Laboratory. The program is capable of doing three-dimensional calculations, but because of the large computational time involved, most of their calculations have been two-dimensional cases. Applications have included two-dimensional, transonic, inviscid flow around a NACA 0012 airfoil; one-dimensional shock propagation (which exercised the adaptive mesh capability of the program); a laminar extrusion problem; and several filter bed calculations.

#### Combustion

Their combustion activities are managed by Jean-Pierre Patureau. His

group consists of approximately 10 people. A recent study concerned the development of a quasi-three-dimensional parabolic Navier-Stokes code to predict the radiant emission from petroleum flares. The application was to off-shore oil platforms where it was hoped that with a more accurate model of the temperature profiles of the flame, smaller platforms could be built which would still conform to environmental standards. They found that in order to achieve stable calculations they had to introduce a rotation function and a pseudo stream function. A  $k-\epsilon$  turbulent model was used. The chemistry was handled by a single global reaction which was controlled by Magnussen's eddy dissipation concept. For soot production, a modified Tesner model was used, adjusted to account for the large size of the flame (approximately 15 m). The radiation from the flame was computed by a six-flux model in which the flame was first divided into regions and then into facets whose radiant contributions were individually calculated and summed. The grid spacing in the cross-section perpendicular to the jet axis varied from  $15 \times 30$  at the base of the flame to  $45 \times 85$  within the flame. The results of these calculations, for both calm air and with cross-wind conditions, agreed well with experimental radiometer measurements made at a site in the south of France. They found that the American Petroleum Institute (API) flame model, currently being used to estimate the radiant energy emitted by flares, is far too conservative. In fact, the radiation estimates obtained from the API model are from one-and-a-half to three times the actual amount of radiation emitted. Thus it appears that drilling platform size can be made much smaller (and therefore cheaper) than previously thought.

Encouraged by these calculations, they are currently developing a combustion model for diesel engines in support of the French Navy's interest in reducing the size of their marine engines. This activity will be undertaken with possible collaboration with the Joint Research Committee (JRC), which is a consortium of European engine manufacturers engaged in developing advanced computational methods for internal combustion engines.

Other combustion-related work involves the calculation of supersonic mixing in a chemical laser. In these calculations, a deuterium jet at a Mach number of 4 and a fluorine jet at a Mach number of 5 are allowed to impinge at a shallow angle. In the calculations, a time discretization scheme allowed automatic, time-step updating starting from

the convective transport time scale and ending with the limiting time step (chemical reactions). Spatial discretization was carried out using finite element theory. For determining the pressure, a semi-implicit algorithm was used. This was necessary because of the importance of viscous dissipation within the mixing layer and because of the low ambient pressure.

Out of approximately 40 candidate reactions, the 11 most critical reactions were selected for inclusion in the calculations. The selection was made on the basis of a sensitivity analysis carried out by means of a variational technique. This approach appears to be quite general and Bertin intends to use it to streamline the operation of many of its programs.

Only a limited comparison with experimental data was made. I may be able to obtain some data for them from the Air Force Weapons Laboratory (AFWL) which will be of help to them in further verifying their calculations.

The division currently has under development a small, high-pressure, methanol/liquid-oxygen, thermoelectric power generation system for marine applications. The system uses a small, compact (gas-turbine type) combustor and a swirl burner to produce 900°C gas. Both the thermoelectric elements and the carbon dioxide/water condenser are cooled by sea water. Calculations are now under way to design the walls of the combustion chamber using well mixed reactor theory. Another engine-related activity involves a lithium engine for torpedo propulsion.

#### Hydroacoustics

They have a fairly large activity in the hydroacoustics area, which was described to me by Daniel Leducq. They are involved in tests and numerical modeling work directed toward examining the effects of local roughness, pressure gradient, and polymer injection on hydrodynamically generated noise. The application is to sonar systems and laminar hydrophones. In connection with sonars there are, in fact, three sources of flow noise to be concerned with: that due to the towing cable, the carriage, and to the sonar itself. By injecting a polymer (Polyox) ahead of the sonar, noise reductions of an order of magnitude were achieved. Even greater reductions in hydrodynamic noise were achieved when the Polyox was mixed in the water of the towing tank rather than being injected from the sonar. At the present time, attention is being focused on developing an understanding of the noise reduction mechanism. It is thought

that the introduction of the polymer produces an anisotropy in the flow. This diminishes the velocity fluctuations perpendicular to the wall which are believed to be responsible for hydrodynamic noise generation.

In submarines, ballast doors, cooling water inlet and outlets, and the conning tower are important noise sources. Noise produced by these sources is particularly serious because it is of low frequency and thus can be detected at long range. Leducq ran a number of experiments to determine if a fairing over the leading edge of the ballast doors would reduce the noise level. What he found was that the fairing succeeded in moving the natural frequency of the ballast door cavity away from the vortex shredding frequency. This produced an order of magnitude decrease in the sound level.

Bertin is also involved in internal hydrodynamics; one example is generation and propagation of sound in pipes. This work involves experimental and analytical prediction of the transfer matrix in pipes and exploring the sound generated by orifices.

There were several other hydrodynamic problems mentioned, including drag reduction by compliant surfaces (it looked to me as if this work was done several years ago), drag reduction in pipe lines due to polymer addition (also done several years ago), and marine hovercraft design (their N500 was used in commercial service across the Channel). More recent activity features the use of cavitation to enhance the cutting characteristics of high pressure jets and to provide a high intensity noise source for acoustic studies. They have also modeled the extrusion of non-Newtonian fluids such as melted polymers, powdered metals, and rocket propellant.

#### Conclusion

I received a list of topics on which Bertin would like to establish some sort of cooperative arrangement with the Navy (involving at least an exchange of information). These topics were:

1. Drag reduction and hydrodynamic noise reduction by air bubble injection in the boundary layer
2. Development of hydraulic silencers
3. Use of ferro fluids for transducers and peristaltic propulsion
4. Pump noise reduction by appropriate hydroacoustic design.

Bertin's strength lies in application rather than invention. They are, in

every sense of the word, an applied research organization. They excel at technology utilization and are involved in a number of projects which seem to me would be of considerable interest to the technology-related sectors of the Navy.

12/16/85

FLUID MECHANICS RESEARCH AT LABORATOIRE  
NATIONAL D'HYDRAULIQUE

by Eugene F. Brown.

Laboratoire National d'Hydraulique (LNH) is one of eight departments of the Division of Studies and Research of Electricité de France (EDF). It is located in Chatou, approximately four miles west of Paris. The laboratory is divided into five groups: Maritime Hydraulics, River Hydraulics, Modeling and Field Testing, Research, and Industrial Fluid Mechanics. I visited the last two groups.

The laboratory employs approximately 130 people, of whom 55 are engineers and the remainder members of the technical and secretarial staffs. Approximately 60 percent of the laboratory's funding comes from EDF, which is the nationally owned company responsible for power plant construction and electricity production and distribution throughout France. The remainder of its revenue comes from research contracts with other national companies and private organizations.

LNH has traditionally been involved in studies related to EDF's hydroelectric generating operations. Recently, however, this activity has diminished and research connected with the development of thermal power plants (including nuclear) has taken its place. In fact, much of the current activity is related to problems involving the operation and safety of power plants (principally nuclear power plants) and problems related to environmental concerns in rivers, the sea, and the atmosphere connected with both power-plant siting and operation. In these areas, fluid mechanics plays an important role.

LNH is particularly well endowed in terms of computational facilities. Their computing facilities consist of one CRAY X-MP and four IBM 3090's located in the Computing and Applied Mathematics Division at Clamart, south of Paris.

The Research Group is headed by Dr. A. Hauguel. He said that his group was

one of the first in France to capitalize on the use of computational fluid dynamics for solving hydrodynamic problems, particularly those related to coastal hydraulics. Consequently, his group is the most experienced of any group within EDF in the use of numerical methods and is often called upon for advice by the other divisions. Hauguel is very well known in the European hydraulics community and is a frequently invited speaker at international meetings.

The goal of the Research Group is to develop general fluid mechanics programs for use by other groups within the laboratory. This involves several phases: selection or development of an appropriate mathematical model, selection or development of an appropriate numerical technique to solve the equations, and comparisons with experiments in order to verify the results of the calculations.

Figure 1 is a schematic indication of the capabilities of the various Navier-Stokes programs developed by the group. Applications, as well as the characteristics of each of the programs, are indicated. The capabilities of the programs include:

- Two and three-dimensional flow
- Shallow water or depth-averaged equations (finite element and finite difference)
- Linear or curvilinear coordinates, incompressible or compressible flow.

Problems which have been solved include:

- Dams
- Thermal effluent in rivers and harbors
- Internal flow in heat exchangers and nuclear reactors
- Plumes from cooling towers
- Storm surge and tidal current modeling
- Surface waves
- Two-phase flow
- Diffusion flame calculations.

A feature shared by most of the programs is advection/convection operator splitting, which aids in modularizing the resulting programs. This contributes to their ease of use and allows the programs to be readily adapted to a wide variety of spatial discretization schemes. The advection step is solved by a characteristics method and the diffusion step is solved by a finite element method. A convected test function is incorporated in the diffusion step to assure the conservative property of the calculations. In practice, an almost dissipation-free

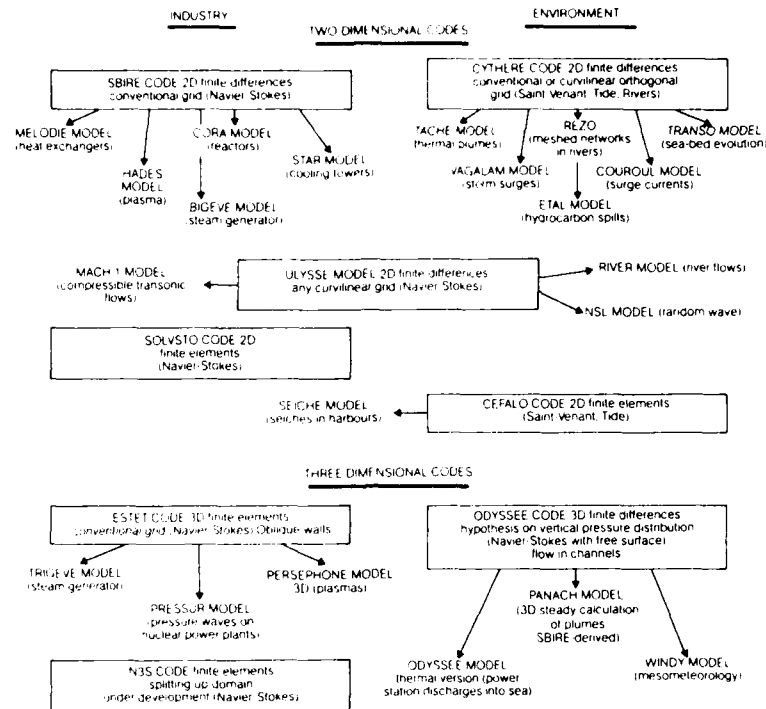


Figure 1. Navier-Stokes codes at LNH.

calculation is produced, and the proper phase relationships are accurately maintained.

Some recent work in the group has included an attempt to develop a turbulence model capable of accurate prediction of the noise generated by separated flows such as those found downstream of orifices. A reconstitution of the turbulence model employing a new energetic variable and sound-speed/velocity-gradient correlations was developed. This work is clearly in its early stages, and no experimental data is yet available to compare with the calculations.

A project on the modeling of free-surface flows was recently completed by O. Daubert. A representative example of these calculations is shown in Figure 2. The calculations were carried out with a version of the ULYSSE Program. It was a finite difference calculation which employed coordinate shearing based upon the shape of the wave surface. A fully nonlinear free-surface boundary condition was used in the calculations. Calculations were carried out for both regular and irregular waves up to the point of wave breaking where a damping mechanism was added in order to continue the calculations. Obstacles can be modeled on the bottom of the channel and free-floating obstacles can be placed on

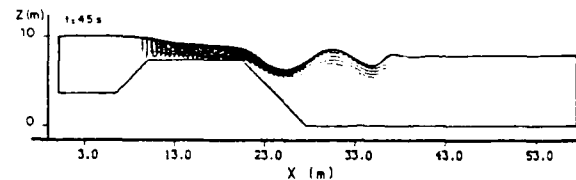


Figure 2. Calculation of steady flow over a sill.

the surface. Calculations showing waves generated by the vertical plunging of such obstacles were shown. A mixing length turbulence model was used in the calculations. Wind shear on the surface can be included by means of a quadratic correlation.

Their newest program is N3S. This is a finite element program for three-dimensional flows which was begun about three years ago and based on the FIDAP Program which they bought from the United States. By careful management of data exchange within the program, they have been able to achieve a computational time of approximately 2½ seconds per 1000 nodes per time step. The intention is to make this a "super program" which will eventually replace their present

collection of specialized computer programs.

In connection with the development of N3S, some special problems have arisen. One is the relative slowness of the convergence process. Considerable progress has been made in speeding up the calculations by using a new type of local viscosity preconditioning. Another problem is related to the boundary conditions which must be imposed in conjunction with the  $k-\epsilon$  turbulence model. This was overcome by using a semi-explicit treatment of the diffusive terms and inverting the procedure by which the wall boundary points were handled.

I also visited the Industrial Fluid Mechanics Group, which is headed by P.L. Viollet. Their work is primarily in internal hydrodynamics. Although the group is largely dependent on the Research Group for programs, they often need to make substantial modifications in these programs because of the complex geometries of industrial devices. A good case in point was the need to replace the usual law-of-the-wall equation by a near-wall turbulence calculation. This was necessary because of the limited resolution of the calculations in complex geometries such as reactor cores (see Figure 3). This technique is not unlike the PSL technique developed by Launder. The near-wall turbulence calculation produced a much better solution than the law-of-the-wall calculation in a test problem consisting of a wall-driven cavity.

Difficulties often occur in regions near sharp corners where the specification of the local wall normal needed in the specification of the wall boundary condition becomes undefined. It was found that proper calculation of the pressures in separated regions can be obtained if an upstream rather than a average normal is used at corners.

Viollet's group is working on a two-phase (bubbles and water), cross-flow heat exchanger calculation. The approach which they are using is a two-fluid model which accounts for the diffusion of the bubbles from the separated region downstream of the tubes. What the method currently lacks is a treatment of the bubble breakdown phenomenon. What happens in the wake of the tubes is a tearing of the bubbles due to the large velocity gradients present there. This bubble destruction phenomenon is poorly understood and represents an interesting research topic in itself. In fact at EDF's suggestion, the Centre National de la Recherche Scientifique (CNRS) has undertaken a research project to attempt to understand this problem. Because of the possible relationship of

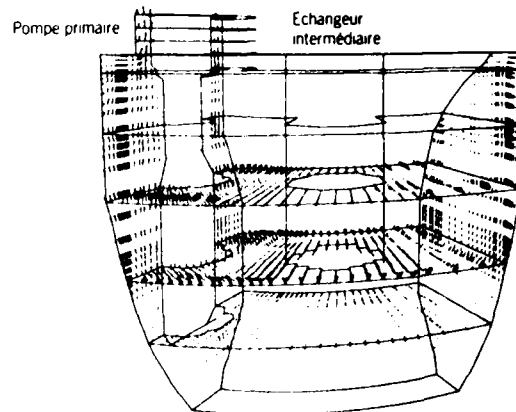


Figure 3. Sector of a fast breeder reactor.

this research to the mechanism of drag reduction by air-bubble injection, this research might be a profitable activity for the Navy to follow. I will request an update on this research during my next visit to EDF.

Through the publications which they gave me I have become aware of other work (not specifically mentioned during this visit) of possible Navy interest. One is a study of the mixing of planar co-flowing jets and the other is transverse injection of a jet into a free stream. In addition to this they have a long-term interest in large eddy simulation (LES) and have contributed to EUROMECH 199--Direct and Large Eddy Simulation of Turbulent Flows (see ESN 40-3:98-100 [1986]).

In summary, LHN is a very active contributor to the field of hydrodynamic calculations; however, their preoccupation with coastal hydraulics and internal (industrial) flows causes their activities to be of less interest to the Navy than would otherwise be the case. Nevertheless, there is sufficient work going on in the fundamental areas of algorithm development, bubble breakdown, LES, and hydrodynamic noise generation to make it productive for the Navy to keep up to date on their activities. To facilitate this process, ONRL has been placed on the mailing list to receive all LNH technical reports. In addition, I am planning on making another visit to EDF, accompanied by Dr. Thomas Warfield, ONRL's Liaison Scientist for underwater acoustics, to learn more about their hydrodynamic noise research.

1/27/86

## Physics

### LASERS AND ELECTRO-OPTICS AT CISE IN MILAN

*by Paul Roman. Dr. Roman is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on assignment until September 1987.*

Basic optics, laser sources (including high-power laser systems), optical equipments and fiber optic sensors are the focal points of the Electro-optics and the Power Lasers Sections in the Research and Development Division of the Centro Informazioni, Studi, Esperienze (CISE--Center of Informations, Studies, and Experiments), a vast multidisciplinary independent scientific and technical private-joint-stock R&D company located in the Northeastern Segrate suburb of Milan, Italy.

CISE was founded in 1946, essentially as a small scientific research center staffed by a few academics who could attract both government research funds from the new political regime and also from foreign sources, including the US Office of Naval Research. Today CISE employs 550 people, of whom 400 are researchers and technicians. The CISE site covers 80,000 m<sup>2</sup>; the capital stock is about \$10 million. Sixty-five percent of fiscal support comes from the principal stockholders, the Italian Electricity Agency (ENEL), and 20 percent from the Atomic and Novel Energy Sources Agency (ENEA)--this explains much of the specific development work done at CISE. But 10 percent of annual support is still originating from Consiglio Nazionale di Ricerche (CNR), the Italian equivalent of our NSF, and 5 percent comes from private industry.

CISE is presently undergoing a change of profile: goal-oriented work is receiving special emphasis at the expense of basic research. Correspondingly, the officially listed activities of the institution are formulated in appropriate terms. They are as follows: materials, instrumentation and diagnostics, engineering, mathematical models and numerical methods, and environmental work. Nevertheless, these down-to-earth designators do accommodate much basic research.

### Major Electro-optics and Laser Research Areas

Dr. A. Sona, one of the first laser scientists in Italy, is now the Lasers

and Electro-optics Area scientific assistant of the Director General. He acquainted me with the current profile of research in this field. Present activities focus on the following topics:

1. Laser sources:
  - (a) High peak power solid-state slab lasers.
  - (b) Tunable infrared generation by nonlinear effects (pulsed parametric LiNbO<sub>3</sub> oscillator, nonlinear frequency mixing in crystals for spectroscopy in the 1.5- to 20- $\mu$ m region, tunable picosecond laser, four-wave mixing in hydrogen and CH<sub>4</sub>).
  - (c) Tunable laser applications (lidars, CARS spectroscopy, industrial microelectronics applications).
2. High power lasers:
  - (a) Continuous wave CO<sub>2</sub> lasers (up to 10 kW).
  - (b) Analysis of radiation/matter interactions.
3. Coherent optics:
  - (a) Light deflection and scattering by fluids (including time-resolved plasma diagnostics).
  - (b) Deformation and strain analysis (speckle pattern interferometry, double exposure interferometric holography).
4. Optical methodology:
  - (a) Laser interferometry (for vibration and strain analysis).
  - (b) Fiber optic sensors.
  - (c) Fluid state studies by light scattering (using laser Doppler velocimetry; also optical study of phase transitions in binary mixtures).

### Lasers and Laser Systems

Much of the work in this area is oriented toward industrial, machining applications. The simplest development, now completed, was aimed at the construction of a continuous wave operation (CW) CO<sub>2</sub> laser system, with 600 W output. The laser itself is a slow axial-flow model which can operate not only in the CW mode but also pulsed, in which it produces 50- to 800- $\mu$ s-long pulses with a repetition rate of 30 to 1000 Hz; it has a respectable maximum energy per pulse value of 3 J.

The next most interesting model, of which a prototype has been built, is a transverse flow, self-sustained electrical discharge CO<sub>2</sub> laser. It has been designed with two independent discharge channels, and if the two channels are used together, it has a 5-kW CW output; it can also be used to give two independent 2.5-kW laser beams. It operates at a pressure of 30 torr, and uses a 5-38-57 percent mixture of CO<sub>2</sub>-N<sub>2</sub>-He.

The electro-optical efficiency is over 13 percent. The high power value has been obtained by using a stable-unstable resonator. This behaves as an off-axis positive-branch confocal unstable resonator in the gas flow direction, and as a concave-convex stable resonator in the direction of the electric field.

The most interesting design I saw is still in the experimental stage: it is a transverse flow, electron beam, sustained discharge CO<sub>2</sub> laser which easily produces 10-kW power in CW operation and, after further improvements, is expected to deliver up to 15 kW in pulsed operation. I was impressed by the simplicity and relative compactness of the device.

Besides these CO<sub>2</sub> lasers, an interesting variety of both solid-state and gas lasers have been designed at CISE; I can supply a list of characteristics to interested colleagues. Unfortunately, however, I was not introduced to the current research on novel solid-state lasers (including slab configurations); proprietary considerations (rather than lack of time) were probably the reason.

But I learned that a high-power alexandrite laser for lidar applications is now being developed under contract, as well as a Nd:glass slab laser with a 10-Hz repetition rate, to be used in a Thomson scattering system. Moreover, "a continuously tunable 16- $\mu$ m two-color laser with 1-J energy for uranium isotope separation" is being experimented with. (I do not know what this exactly implies.) In addition, it seems that a Nd:glass pulsed laser (5-Hz repetition rate) with 5-J/pulse output has been already realized.

To conclude this section on CISE's laser development program, I would like to emphasize that here we have a very experienced, successful, imaginative group of researchers and engineers, ready and willing to cooperate in novel ventures.

#### Lidar Systems

CISE developed a lidar system based on differential absorption. This device measures the different attenuation of two distinct laser beams whose wavelength is synchronized on the maximum and on the minimum of the absorption band of some specified gas pollutant in the atmosphere. An older lidar system was based on a Nd:YAG pumped dye laser; the current laboratory prototype uses a parametric oscillator pumped by a Nd:YAG laser. It affords continuous tunability between 1.4 and 4  $\mu$ m. It can recognize CO, CO<sub>2</sub>, CH<sub>4</sub>, HCl, and NH<sub>3</sub> pollutants up to 2 km distance, with a sensitivity ap-

proaching a few parts per billion concentrations.

Modifications of the system for other uses are within the capabilities of the research labs.

#### Optical Fiber Sensors

The thrust of the fiber sensor program at CISE is the development of interferometric systems, sturdy and reliable enough for varied field applications. Special emphasis is given to the study of the interaction mechanisms between the fiber and the measurands and to the optical architecture of the fiber optic interferometer.

The interferometric devices so far developed by CISE use phase modulation as a signal to be processed. With devices of this kind, the researchers succeeded in measuring deformations in the range of  $10^{-2}$   $\mu$ e to  $10^3$   $\mu$ e with  $10^{-4}$   $\mu$ e resolution; pressures in liquids with up to  $10^{-6}$  Pa resolution; and temperatures below 300°C with  $10^{-5}$  degree C resolution. Of special interest to the Navy may be a hydrophone system with undisclosed sensitivity for measuring small pressure fluctuations in, for example, hydroelectric basins.

Typical of the current research activities in the fiber sensor group is a recent paper by M. Martinelli and A. Barberis (*Journal of the Optical Society of America*, Vol 2, No. 4 [1985], 603). The authors discuss an arrangement which solves the isolation problem in an interferometric Michelson-type fiber sensor and, at the same time, optimizes the recovery of the signal and prevents unwanted reflection effects. From the theoretician's viewpoint it is interesting that phase modulation and frequency modulation are both treated as the result of fiber-optic-induced phase shift. A new approach was developed that permits direct frequency-modulation-index recovery. Experimental studies confirmed the predicted linear behavior of the fiber-strain-sensor design for four decades of measurand values.

#### Concluding Remarks

While current activities at the electro-optics and laser development groups of CISE are more oriented to industrial goals than they used to be, the research potential of this broad-based, interdisciplinary R&D lab is high and compares favorably with other European independent laboratories. I think that CISE is eager to strengthen research contacts with US agencies, especially with the Navy.

2/2/86



## News and Notes

### ONR LONDON STAFF UPDATE

The ONRL technical staff is relatively small in comparison with the wide range of disciplines and their major subdivisions. The coverage of our reporting at any given time is a direct correlation of the expertise of the staff at that time. As newly arrived scientists and officers settle in and others move on, the coverage shifts, often with a gain of reportage in one area but a loss in another. We believe that over the long run most disciplines are well served, not only in the specific attention they receive (when one of their number is on board) but in the global view where all science ultimately comes together.

An example of the turnover is the loss in November 1985 of Dr. Charles J. Holland, who reported on mathematics, and the subsequent arrival in January 1986 of Professor Jerome Williams, whose liaison work will be in oceanography.

We welcome Professor Williams and look forward to the results of his liaison. He comes to us from the faculty of the US Naval Academy. His primary research work has been in marine optics, and he has devoted much effort to oceanographic instrumentation and marine pollution.

Currently on staff (and their disciplines) are:

#### Scientific Liaison Division

Dr. E.F. Brown (Mechanical Engineering)  
 Dr. K.D. Challenger (Materials Science)  
 Dr. P. Roman (Physics)  
 Dr. D.L. Venezky, ONRL Scientific  
 Director and acting Division Director  
 (Chemistry)  
 Dr. T.J. Warfield (Underwater Acoustics)  
 Prof. J. Williams (Oceanography)  
 Dr. Claire E. Zomzely-Neurath (Biochemistry, Neuroscience, and Molecular Biology)

#### Naval Applications Division

CAPT L.L. Coburn, the Division Director  
 (Aerospace Systems)  
 CDR E.D. Hagee (Surface Weapon Systems)  
 LCDR J.M. Boggio (Undersea Systems)  
 LCDR R.G. Kelley, Jr. (Environmental  
 Systems and Military Oceanography)  
 (vacancy--Liaison Technologist [RPV])

Also new to ONRL staff is myself, C.J. Fox. My promise as editor is to do

my best to maintain the fine standards already established for ESN and look for ways and means to improve its usefulness to all concerned.

C.J. Fox  
 2/7/86

### EUREKA PROJECTS ANNOUNCED

Sixteen collaborative projects worth a total of \$557 million were announced in January 1986 by representatives from the 18 countries participating in EUREKA, the European research program. The program was set up in 1985 to bring together European research in strategic areas including electronics and many others.

EUREKA is a concept proposed as a plan of action by French President Francois Mitterand in early 1985 (see ESN 39-12:570-574). President Mitterand feared that European companies would be co-opted by the Strategic Defense Initiative program of the US. However, the program is described as a civil program for the long-term economic survival of Europe. Eighteen European countries have agreed to participate in the program, accounting for many companies and laboratories both within the EEC and outside. The projects will be designed to produce new, high technology products. It is not just a research program and does not precisely overlap current EEC programs like ESPRIT and RACE.

Details on the operation of a EUREKA secretariat have been agreed, subject to confirmation by the next ministerial conference in the summer of 1986. The basic task of the secretariat will be to function as an information exchange and to provide progress reports and briefing papers for ministerial conferences. Six of the proposed 12 members will be professionals. The group will also approve procedures for exchanging information about EUREKA projects which will go into effect immediately on a provisional basis.

The 16 projects announced are as follows:

- Flexible automated factory for electronic cards. Participants: Inisel (Spain), Eurosoft (France). Cost 30 million European Currency Units (ECU; 1 ECU = \$0.88). Duration: five years.
- European center for image synthesis. Participants: RTL Productions (Luxembourg), Cesar (France). 8.5 million ECU. Five years.
- Automatic design and production of custom chips using direct printing on



silicon. Participants: Brown Boveri (Switzerland), ICL/British Aerospace (UK), Philips (Netherlands), Bull (France), Olivetti (Italy), Saab/Scania (Sweden), Telefonica (Spain). 50-100 million ECU. Three years.

- Integrated circuits. Participants: GEC (UK), Thomson (France). 60 million ECU. Three years.
- Third generation fast moving robots for public safety applications. Participants: CEA in collaboration with Matra (France), Dornier (Germany), Casa (Spain), Csem (Switzerland). 100 million ECU. Six years.
- Expert system for dealing with major plant failures and security control. Participants: Aerospatiale (France), Norsk Veritas (Norway). 30 million ECU. Four Years.
- EUREKA advanced software technology. Participants: CRI (Denmark), Nokia (Finland), SFGL (France). 110 million ECU. Six years.
- Automatic production management system. Participants: Absy (Belgium), Aerospatiale/Bull/Renault (France). 30 million ECU. Six years.
- Automatic system integrated system for neutronography. Participants: Sodern (France), Semer (Spain). 15 million ECU. Four years.
- Chemical waste production. Participants: Solvay (Belgium), Rhone-Poulenc (France). 9 million ECU. Five years.
- Gate turn-off thyristors for application in railway traction. Participants: Thomson (France), GEC (UK). 20 million ECU. Two years.
- Chrome salts substitutes. Participants: Matyk (Austria), Hellenic Tanneries (Greece), Hispano/Quimica (Spain). 2.5 million ECU. Three years.
- Development of automated noninvasive medical diagnostic equipment. Participants: Amis (Denmark), YCSA (Spain). 60 million ECU. Five years.
- Vehicle noise identification. Participants: IMED (Belgium), Porsche (West Germany). 1.5 million ECU. Four years.
- Project to exchange manufacturers' drawings via telecommunications. Participants: Aerospatiale (France), Aer Italia (Italy). 30 million ECU. Five years.
- Development of ceramic and new metallic components for car engines. Participants: (Participating firms from France and Italy not named.) 25 million ECU. Five years.

J.F. Blackburn  
1/30/86

#### THE TRANSPUTER MOVES FORWARD

The transputer made by Inmos Ltd., Bristol, UK, is a key component of the EEC-sponsored super computer project based on the architecture designed at Southampton University (ESN 39-6:252-255). It is also a key component of the Alvey Flagship project for a Fifth Generation Computer (ESN 39-9:418-421).

Substantial delays in the production of the transputer were reported in ESN 39-9:443. However, on 1 October 1985 the 32-bit T414 was launched in London. It is a specially designed combination of a processor, memory, and connector pins on a single chip. Specifically, the T414 is an 84-pin 32-bit VLSI chip measuring 8.7x8.9 mm. It contains the equivalent of 200,000 transistor elements executed in 1.5- $\mu$ m geometry in a complementary metal oxide silicon (CMOS) process using two-level metallizing of aluminum and tungsten silicide.

The processor unit works at 10 million instructions per second and has 2 K bytes of fast static RAM (random access memory). It can address up to 4 G bytes of external memory at 25 M bytes per second. It is programmed in Occam, the parallel processing language developed by Inmos to enable the transputer to execute programs concurrently. Another compiler also permits programs to be run in other high-level language such as C, Pascal, and Fortran.

The four twin Communication Channels, operating at 10 M bits/second, used to link directly to other transputers, makes possible the connection of arrays of transputers using a back frame with minimal peripheral hardware.

The T424, with 4 k bytes of on-chip memory, will be available soon. Inmos is also working on the design of a Floating Point Processor, F424, which will be needed for the Southampton super computer sponsored by EEC's ESPRIT program.

J.F. Blackburn  
1/29/86

#### NEW LABORATORY TOOL FOR MICROBIOLOGICAL RESEARCH DEVELOPED BY ISRAELI SCIENTISTS

One of the most basic tools in microbiological research and diagnosis is a small metal or plastic rod with a tiny loop at the end of it. It is used to test an environmental, food, or clinical sample for the presence of bacteria, the sample being transferred by means of the loop onto a sterile growth medium, usually agar. The procedure,

termed "dilution streaking," has usually been done with a platinum or chromium-nickel loop which has been sterilized in a flame, cooled, and dipped into the sample being tested and then transferred to the growth medium. The loop has to be sterilized several times and streaked repeatedly through the agar growth medium in order to dilute the sample to a level that ensures the growth of individual colonies of bacteria. Dilution streaking with a metal loop is time consuming and is somewhat risky since bacteria might be sprayed into the air and inhaled, thereby causing infection. Disposable plastic loops, which are also used, cannot be sterilized so that several loops are needed for each sample.

Two Tel Aviv University researchers, working with a kibbutz-based plastics firm, have developed a greatly improved plastic loop, called the Multi-Loop. This loop is a slender, four-sided rod with a loop at one end and a sphere at the other. By turning the loop 90 degrees at a time, the researcher or technician can use the sphere to perform four streaking operations. One Multi-Loop thus replaces up to four conventional loops. When a specific amount of fluid is needed for the sample, the loop at the other end, which takes up 10 microliters at a time, is used.

The new multi-loop has been developed by Dr. Mel Rosenberg, head of the Oral Microbiological Laboratory at the Sackler Faculty of Medicine's School of Dental Medicine, Tel-Aviv University, and Dr. Ervin Weiss of the Operative Dentistry Section. It will soon be produced commercially by Miniplast Company of Kibbutz Ein Shemer. Patents are pending in Israel, the US, Japan, and ten European countries.

*Claire F. Zomzely-Neurath*  
1/13/86

#### EUROMECH 203, COMBUSTION THEORY

EUROMECH 203, Combustion Theory, was held 2 through 4 December 1985 at the Cranfield Institute of Technology in Cranfield, UK. The UK accounted for the majority of the participants although France, Spain, Germany, and Poland were also represented. The intent of the meeting was to focus on analytical-approximate methods for modeling homogeneous and heterogeneous combustion. As with most EUROMECH conferences no proceedings will be published.

Large activation energy asymptotic methods played a prominent part in the

colloquium. In his opening remarks, Professor J.F. Clarke (Cranfield Institute of Technology), who organized the colloquium, pointed out that such calculations were begun in the early 70's and much of our current understanding of combustion is owed to these methods. Unlike early calculations which focused on diffusion flames and ignored local temperature sensitivity, many of the papers presented at this colloquium focused on the issue of criticality, thermal runaway, and times-to-ignition.

M. Champion (University of Poitiers, France) described his modeling of spherical flames using high activation energy asymptotics. The results were shown to be in good agreement with numerical simulations and experiment measurements. G. Joulin (University of Poitiers) described his spherical flame calculations which were done for a gaseous combustible premixture seeded with inert particles. In these calculations he found it absolutely essential to include the effects of radiation heat transfer.

In some situations fluid motion plays a vital role in the combustion process. In these cases, familiar fluid dynamics algorithms such as McCormack's method, the total variation diminishing (TVD) scheme, and the flux-corrected transport (FCT) method (developed by J. Boris at the Naval Research Laboratory) were used. In particular, S. Schoffel (University of Kaiserslautern) described his shock-wave/flame interaction calculations using Lax-Wendroff, FCT, and TVD schemes. H. Phillips (Health and Safety Executive, Buxton) described the use of the FCT method for his flame acceleration calculations.

In some cases, a two-fluid approach was used where separate equations were written for the burned and unburned gases. In the case of a solid fuel, separate equations were written for the gas and the solid phases. It is necessary to postulate relations between the two "fluids" and often these are quite arbitrary. For two gas phases, relationships for the flame area, momentum transfer, and heat release function are needed. Phillip's calculations, quite expectedly, turned out to be very sensitive to the manner in which the interface relationships were postulated. In particular, he found that for accurate calculation of deflagration-detonation problems, it is important that the scale of the flame front be properly modeled. Otherwise the overpressures will not be correctly predicted. P.H. Taylor (Thornorton Research Centre, UK) demonstrated that the local wall geometry must also be properly modeled because obstacles in

the flow can serve as flame holders which greatly increase the flame speed.

The meeting succeeded in bringing together chemists and the computational fluid dynamics community in an atmosphere where discussion was encouraged and a free interchange of ideas took place. Combustion theory is now advanced to a point where it is possible to incorporate more complex reactions in the combustion calculations. Consequently, the timing of this meeting was most appropriate.

*Eugene F. Brown*  
2/4/86

#### FLUID DYNAMICS AT THE AIRCRAFT RESEARCH ASSOCIATION, LTD.

Aircraft Research Association, Ltd. (ARA) was founded in 1952 by fourteen UK aircraft firms with the declared objective of designing, building, and operating a large (9'x8') transonic wind tunnel. Since that time, additional facilities have been added including a 2'x2' supersonic tunnel, a hypersonic tunnel, a two-dimensional tunnel for testing airfoil models, and a Mach simulation tank for the calibration of powered engine simulators. In addition to these facilities for conventional airframe and missile testing, they have capabilities for specialized tests such as propulsion-system installation effects and external store release.

Their in-house computational facilities include a Prime 400 minicomputer with an array processor and a micro VAX II. At the present time they have a connection with the Honeywell Multics/CRAY 1S at RAE Farnborough. Next year they will be connected with the CRAY X-MP at CRAY Research, Bracknell.

Throughout the years the organization has maintained its original objective: to supply experimental testing facilities in support of aircraft design and modification. Tests have been made on models representing projects from every major UK aircraft project. Much work has been completed on European co-operative ventures such as the Tornado, Jaguar, Airbus, and Concorde.

Approximately 10 years ago, applied and theoretical aerodynamics sections were set up to conduct research in the area of propeller design and to undertake activities in the rapidly developing field of computational fluid dynamics (CFD). These two sections have recently been combined to form the Applied

Fluid Dynamics and CFD Division, headed by A.J. Bocci. The Applied Aerodynamics department is currently involved in design work for conventional as well as advanced prop-fan propellers and the design of laminar wing shapes for small executive aircraft. Some computational work is done to support their propeller flow activities; however, the majority of the computational efforts are located within the CFD department.

The CFD department is headed by C.R. Forsey and consists of eight individuals, four of whom have PhD's. They represent a very active and capable group who have close contacts and personnel exchanges with Dr. Antony Jameson's group at Princeton. Their philosophy is to develop their codes in-house rather than purchase codes written by others. Their code development work has focused on writing codes for specific applications such as inlets, airfoils, and propellers, and performing work on various aspects of the basic flow algorithms. This includes investigation of methods such as approximate factorization and multi-grid techniques. The CFD department is largely funded by the UK Ministry of Defense.

They have developed a patched Euler/boundary-layer method using Jameson's finite volume technique for calculating turbofan afterbody flow. It has produced results which demonstrated excellent agreement with afterbody pressure measurements obtained at Rolls Royce. They are presently extending this code to separated flows and hope to eventually combine this program with a previously developed inlet program, and thus produce a code capable of calculating the flow field for an entire nacelle.

An important component of their work in the basic flow algorithm area is a fundamental study of methods for carrying out multi-block calculations. This is an extremely important technique since, in principle, it allows calculations of flow over complex shapes, such as complete aircraft, to be calculated. This work, directed by Forsey, employs the use of nonoverlapping blocks containing grids which are globally smooth. The grid generation is based on bicubic surface patches and has been employed in connection with an explicit finite volume Euler algorithm to solve problems such as multielement airfoils and pylon/store geometries.

Originally begun as only a subsidiary activity, computational fluid dynamics at ARA has grown into a strong, self-contained, independent, self-supporting group which has made many solid contributions to the CFD area. My

impressions are that the role of CFD within ARA is assured and as it continues to grow, that its financial base will broaden and its research will begin making an impact on the complex aerodynamic problems which are today amenable only to experimental testing.

*Eugene F. Brown*  
2/3/86

#### SPECKLE VELOCIMETRY AT VON KARMAN INSTITUTE FOR FLUID DYNAMICS

Professor Michel Riethmuller of the von Karman Institute for Fluid Dynamics (VKI) in Rhode-St-Genèse, Belgium, has obtained two-dimensional measurements with his speckle velocimetry equipment and hopes to be making three-dimensional measurements in the future.

Speckle velocimetry allows simultaneous flow visualization and velocity measurements within a flow field. The technique involves seeding the flow with small particles and illuminating the plane of interest with a sheet of pulsed laser light (either from a pulsed laser or an optically chopped CW laser) to obtain a multiple exposure photograph of the particles as they travel with the flow. Streamlines can be obtained directly from the multiple-particle images. The velocity and flow direction are obtained by illuminating the photographic negative with a laser probe. This produces fringes in the Fourier plane of a lens. The velocity is inversely proportional to the spacing of these fringes and the flow direction is perpendicular to them.

A 1.7-W argon laser was used as the light source which was modulated by a mechanical chopper producing 20-ms pulses separated by 3-second intervals. An alternative light source was a 7-W argon-ion laser with a Bragg cell used as a chopper.

The optical processing produces a two-dimensional Fourier transformation of the image. The fringe images are acquired, digitized, and stored on video boards. The processing of the image can be accomplished by either one-dimensional averaging or with the average autocorrelation technique.

The principle of one-dimensional averaging is to obtain a periodic signal by averaging over the rows of the picture, perpendicular to the fringe direction. Only a few seconds are required on the Institute's PDP 11/34 for the calculations. A disadvantage of this

method is the necessity of measuring independently the angle of the fringes by superimposing a computer-generated line on the digitized picture and adjusting its position until it is parallel to the fringes.

This problem can be bypassed by using the average autocorrelation technique, which successively computes the velocity components along independent directions. However, this method is computationally intensive. It is not unusual for the determination of one velocity component to require 45 seconds.

Riethmuller has made velocity measurements in a Rayleigh-Bernard cell, in a vortex flow produced by a submerged pulsating jet, and in the transition region of a round gas jet at low Reynolds numbers. In the case of the Rayleigh-Bernard experiment, accuracies on the order of one-tenth of a percent were obtained.

The prospect of making three-dimensional measurements with this technique is an exciting one. Being able to obtain quantifiable flow maps will be a great help in unravelling the intricacies of complicated flows such as three-dimensional shock-wave/boundary-layer interactions.

The significant advantage of speckle velocimetry over LDA is its ability to picture the entire flow field simultaneously. It has the additional advantage that velocity information at each point is, in effect, stored on the negative. Thus, long after the experiment is complete, it is possible to return to the negative and make measurements in regions which were previously unexamined.

*Eugene F. Brown*  
1/27/86

#### COMPOSITION OF LASER BEAMS AT CISE

The power-laser group of CISE, a large independent private R&D company in Milan, Italy, has developed a prototype of a flexible laser-beam-combining optical system. (A broad review of CISE's work in lasers and electro-optics can be found in this issue of *ESN*; see page 139.) The significance of this achievement is that it permits the (noncoherent) joining of relatively low-power and reliable laser sources into a very

powerful single laser source. Even though CISE is developing the system for industrial applications (to feed  $N$  workstations with different levels of output power by combining a maximum of  $K$  individual laser sources), other applications, including laser weapons, are surely conceivable.

The block diagram of the system is represented in Figure 1. Block L represents the  $K$  laser sources. In the current system  $K=3$ ; i.e., CISE uses three CW  $\text{CO}_2$  lasers, with open resonator cavity configurations. Each delivers 2.5-kW power. The unit denoted by D optically decouples the laser sources from the addressing optical system that follows it. Block D is composed of  $K$  sets of two mutually facing plane copper mirrors each. They are adjustable.  $K$  power monitors,  $K$  mechanical shutters, and  $K$  beam-shape visualization units are also included in this block. One purpose of D is to achieve easy means of re-alignment. Block S is the most original part of the system. It serves to combine the input beams as needed. It consists of an addressing unit and a summing unit. The former, consisting of  $K$  plane copper mirrors mounted on pneumatic slides moving in the direction orthogonal to the beams, is used to direct the selected individual beams toward the summing unit. The summing unit is, of course, the crucial element in the system. It is shown, for the  $K=3$  case of the prototype, in Figure 2. The optics is clear: naturally, it is assumed that the individual laser outputs have an annular cross section. Block I, the so-called optical group, directs the  $K$ -S beams (where  $S=2, \dots, K$ ) to  $K$ -S work stations located in C. Block I consists of  $K$  plane copper mirrors which direct the single beams, and one additional, larger mirror which directs the composed beam.

As should be obvious from the above, the prototype can ideally deliver 0, 2.5, 5.0, 7.5 kW to any number of arranged workstations. Two problems were encountered in the experiments: beam point stability of the sources, and mechanical stability of the optical components. The active system is microprocessor controlled, which will eventually involve automatic alignment control as well. Because of losses on the (many) mirrors, theoretically 9.5-, 15.5-, and 14.5-percent power losses can be expected for the cases of one single laser beam, a beam made up of any two independent beams, and a beam made up of all three independent laser beams. Preliminary experiments conform with the predictions. They also show that the beam coming out of the summing unit has

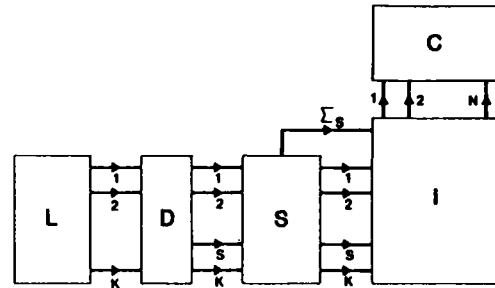


Figure 1. Block diagram of system.

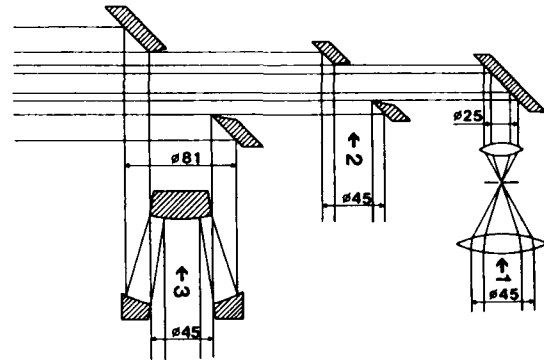


Figure 2. Summing unit scheme for  $K=3$ .

better focusability than a single beam of equal power can have.

Paul Roman  
11/30/85

#### LASER GYROSCOPE DEVELOPMENTS IN THE UK

Two firms in the UK, British Aerospace and Ferranti Defence Systems, seem to have made substantial progress in the area of ring laser gyroscope systems.

British Aerospace received an initial contract of about \$1.4 million from the Ministry of Defence for supplying 12 gyros to be used as the main navigational system of the Anglo-Italian EH101 helicopter. It appears that this aircraft, using the ring laser gyroscope as standard navigational equipment, is the first of such built outside the US.

The ring laser has a 300-mm path length and will be first deployed on the EH101 when it goes into production in 1989. British Aerospace hopes to gain an additional contract worth about \$16 million.

The Avionics/Army Avionics division of British Aerospace engaged in laser gyro development is located near London at Bracknell and grew, so to speak, from the Sperry Gyroscopes Company. Apart from the aircraft-suited gyroscope noted above, the researchers are also doing pioneering work on ship-based and on missile-inserted laser gyroscopes (with 700- and 120-mm optical path lengths, respectively). Their lead-profile is the field of 3-axis gyroscopes.

The Navigation Systems Department of Ferranti Defence Systems, Ltd. (Edinburgh, Scotland) is another contract-winner in the field. The Ministry of Defence awarded Ferranti \$1.2 million to provide two production laser gyroscope strap-down inertial navigational systems for evaluation in a high performance military aircraft environment. The systems should be supplied by Ferranti by early 1986. They will be required to meet the US Air Force ENAC-77-1 standard.

The smaller of the two systems will employ Ferranti's own Type 160 ring laser gyroscopes. These have a 430-mm optical path length and, as is usual, have He-Ne for the lasing medium. They are constructed inside a triangular monobloc of very stable glass-ceramic material. In addition to the gyro, the system will contain 3 Ferranti accelerometers, interface electronics, navigational and sensor computers, and the power supply.

A larger, less sophisticated system prototype has already undergone successful flight trials.

of the beams were used to achieve operation in a way which allowed growing a layer within less than 0.3 seconds. In this manner multiple quantum well devices could be manufactured with well-width from 5.5 nm down to only 1.3 nm. (Note that the width of a monolayer would be 0.28 nm.) With decreasing width the wavelength reduces correspondingly from 837 nm down to 707 nm. This device is the shortest wavelength room-temperature injection laser with only GaAs in the wells that has ever been produced. It has 20 quantum wells, each 5 monolayers thick.

Peter Blood, the scientist in charge of the project, believes that with the available technology, layers one atom thick could be manufactured.

Good uniformity within each monolayer over an area of 5 cm in diameter was achieved by rotating the substrate about 120 revolutions per minute (i.e., two revolutions per monolayer). The growth process was fully computer controlled. The actual lasers had a size of 0.3 mm x 0.3 mm.

Structures with 2.5-nm-wide wells (and CW operation at 760 nm) can now be fabricated on a standard production line. The threshold current is lower than for conventional devices operating at longer wavelengths.

Paul Roman  
1/31/86

Paul Roman  
12/19/85

#### PHILIPS PRODUCES SHORTWAVE QUANTUM WELL GaAs LASERS

Quantum well structures are becoming more and more standard devices, with ever-improving characteristics. Recently I learned about a case in point. Scientists at Philips Research Laboratories in Redhill, UK, demonstrated that GaAs lasers can be fabricated which operate at room temperatures in the visible part of the spectrum, down to as low as 707 nm. The devices studied are quantum well lasers, produced by molecular beam epitaxy. Tantalum shutters in front

#### ONRL COSPONSORED CONFERENCES

ONR, London, can nominate two registration-free participants in the conferences it supports. Readers who are interested in attending a conference should write to the Scientific Director, ONRL, Box 39, FPO New York 09510.

The Interaction of Molten Salts and Metals: Current Understanding of Hot Corrosion and New Approaches to Practical Problems, 2-4 July 1986, York, UK.

International Optical Computing Conference, Jerusalem, Israel, 7-11 July 1986.

Naval Applications and Environmental Chemistry of Organotin, 11 September 1986, Padua, Italy.

Sixth International Symposium on Gas Flow and Chemical Lasers, Jerusalem, Israel, 8-12 September 1986.

SCIENCE NEWSBRIEFS FOR FEBRUARY

The following issues of *Science Newsbrief* were published by the ONR, London, Scientific Liaison Division during February. *Science Newsbrief* provides concise accounts of scientific developments or science policy in Europe and the Middle East. Please request copies, by number, from ONR, London.

<u>Science Newsbrief Number</u>	<u>Title</u>
4-1	Seminars on Geophysical Fluid Dynamics at the University of Cambridge, UK, by LCDR Rich Kelley, USN.
4-2	Mini Leak® a New and Easily Activated Gel for Preparation of Stable Immunoabsorbents and Affinity Matrices, by Claire Zomzely-Neurath.

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JANUARY AND FEBRUARY MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during January and February. The *MAS Bulletin* is an account of naval developments in European research, development, test, and evaluation. Its distribution is limited to offices with the US Department of Defense. DoD organizations should request copies of the *Bulletins*, by number, from ONR, London.

<u>MASB Number</u>	<u>Title</u>
1-86	Submarine Rescue Sphere Tested Successfully
2-86	A Millimeter Wave Helix TWT Developed by EEV in the UK
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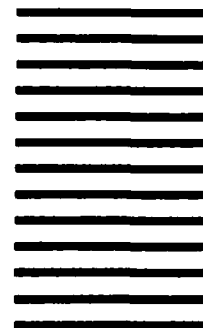
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